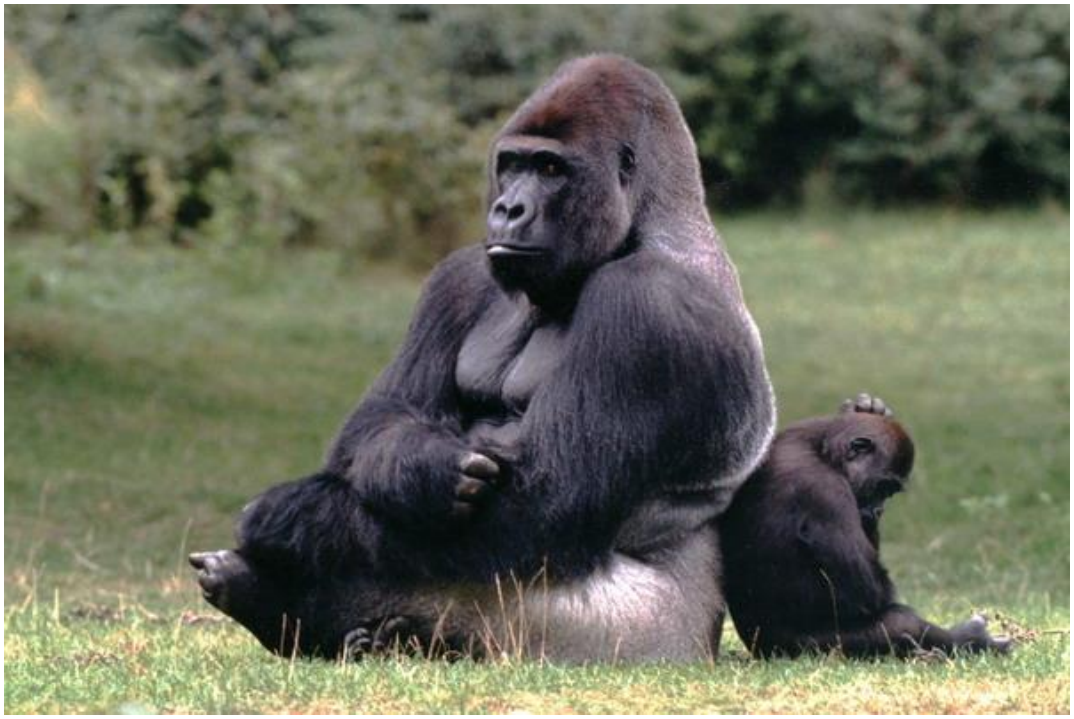

EAZA BEST PRACTICE GUIDELINES

Great Ape Taxon Advisory Group

Western Lowland Gorilla
Gorilla gorilla gorilla

2024
(3rd Edition)

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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.

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 providing information about different aspects that should be taken into account when managing gorillas in captivity to ensure a healthy and self-sustaining population, helping to develop 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 (OPA).

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 better knowledge about keeping this magnificent species in the appropriate and best possible way. To regularly consult the guidelines and contact TAG members with any concerns or queries is recommended.

Acknowledgements

This is the 3rd edition of the husbandry guidelines; first edition was published in 2006 and second in 2017.

The present edition involved revising these Best Practice Guidelines into the latest EAZA required format along with some updating of the content.

The authors would like to reiterate their thanks to Dr. Christian Schmidt, Dr. Werner Kaumans, and Dr. Ellen Krebs for their contribution towards the original Husbandry Guidelines, the precursor text of which formed the basis of these Best Practice Guidelines.

Contents

SECTION 1: BIOLOGY AND FIELD DATA

The genus *Gorilla,* biology and field data.

BIOLOGY

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 2021 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 Morphology

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 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 Physiology

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). This close contact is very important; it will help the infant to survive if the mother dies (Morrison et al., 2021).

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; Robbins & Robbins, 2021). 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.

1.4 Longevity

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.

FIELD DATA

1.5 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.

1.6 Conservation status / Zoogeography / Ecology

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 Strindberg et al (2018). The numbers of western lowland gorillas and Grauer's gorillas have decreased considerably during the last decades (Plumptre et al., 2021).

The latest numbers and estimates:

Cross River gorilla: 250–300
Western lowland gorilla at least: 300,000
Grauer´s gorilla: 6,800
Mountain gorilla (Virunga Volcanoes: 604 ; Bwindi: 459): 1,063

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.

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: https://www.arrctaskforce.org/a-p-e-s-database

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).

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 km² in the Virunga Volcanoes, but over the years it may be much larger (Watts, 1998; 2000b). Areas of 20–30 km² were recorded in western lowland rain forest (Tutin, 1996; Remis, 1997a) and 30–40 km² 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).

1.7 Diet and feeding behavior

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; Lodwick & Salmi 2019). 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).

1.8 Reproduction

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 Behaviour

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 herbaceous 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; Rosenbaum et al., 2015). 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 chest beat 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 Biology and Field Data references

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SECTION 2: MANAGEMENT IN ZOOS AND AQUARIUMS

2.0 Our Welfare Commitment

The practical guidelines in the following chapters for gorillas reflect our current knowledge about their most important housing requirements and are intended to provide the best possible welfare for the animals in our care. A shared definition of welfare shall help gorilla/orangutan holders to better understand our standards in husbandry for this species. The WAZA Animal Welfare Strategy (Mellor et al. 2015) is providing a structured and unifying framework for managing and assessing animal welfare in zoological institutions. Throughout the Gorilla EEP Best Practice Guidelines we follow the vision of this welfare strategy. Gorilla holders should direct their caring attention and efforts towards the highest categories of Maslow's hierarchy of wellness and well-being. That means besides the basic physiological needs, veterinary care and safety needs, zoos should provide gorillas with the best possible welfare which includes covering their social needs and provision of mental stimulation and choices (Fig. 1).

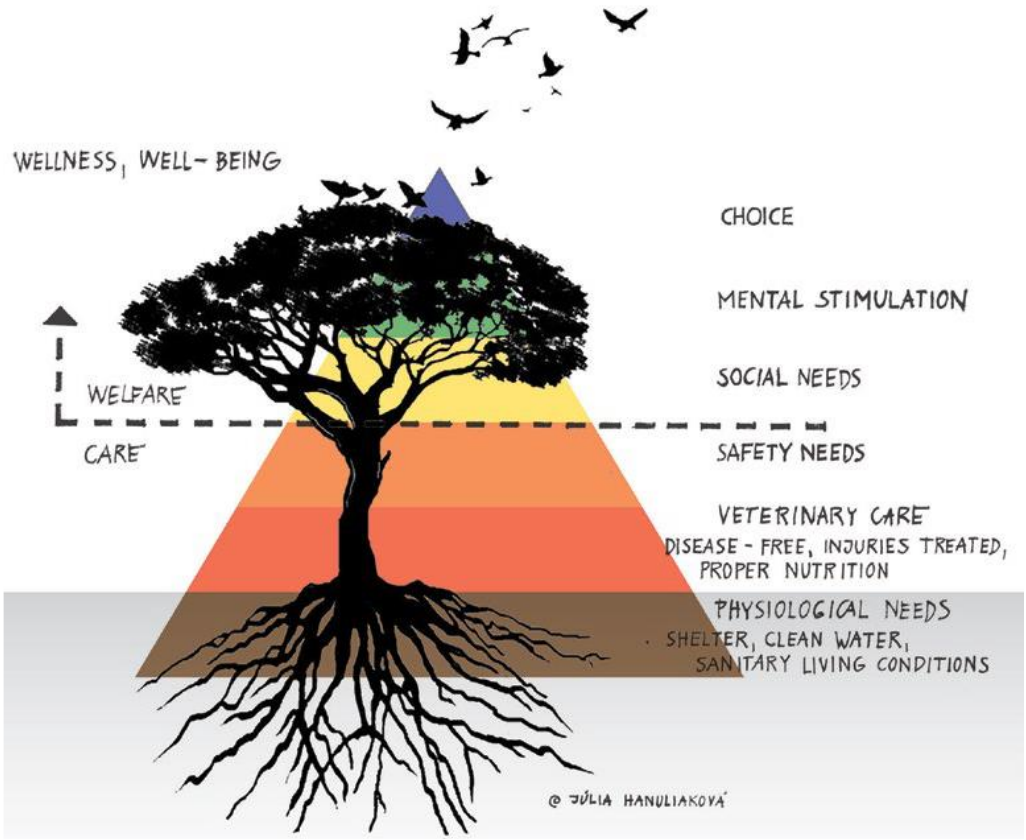

Figure 1: *the aspiration of the WAZA Animal Welfare Strategy is to direct animal welfare attention towards the highest categories of Maslow's pyramid of wellness and well-being. The tree's roots represent the critical foundational requirements for survival, including nutrition systems, understood through experience and science. In the trunk, health care meets the animals' physical and safety needs. The crown is the site of the most varied and complex welfare-related activities that the best zoo and aquarium design and management would make available to the animals. The birds taking flight from the tree represent perhaps an ideal of zoos and aquariums—retaining and encouraging natural abilities. As a tree provides a complex habitat for other*

species, a zoo or aquarium can foster the welfare of animals beyond its own confines. (cf. WAZA Welfare Strategy, 2015)

Animal welfare is a difficult concept to work with as it is not easily defined nor measured. Different scientific, economical, ethical and cultural backgrounds influence our conception of animal welfare (Veasey 2017, Fraser 2009). **The WAZA Animal Welfare Strategy refers to the following helpful description of animal welfare as an underlying basis (World Organisation for Animal Health – OIE):**

"Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry and humane treatment."

Animal welfare is regarded as the **overall state** of an individual. Both negative and positive experiences are significant for welfare. The animal's welfare state reflects the balance between them. The **animal's welfare** will be on the **negative** side when negative experiences predominate, **neutral** when the negative and positive experiences are in balance overall, and on the **positive** side when positive experiences predominate. Our aim is that this balance is positive. However, when is an animal's welfare state positive? In general, animals experience a positive state of welfare when their physical and behavioural needs are met and when the environment provides them with complexity, rewarding challenges and choices over time (Bernstein-Kurtycz 2015). This does not mean that all states of discomfort should always be eliminated for all individuals. This is neither a naturalistic approach nor is it always possible, e.g. during transport, an introduction or rank reversals. Hence, stress is inevitable for wild animals and as such have evolved stress responses as adaptive mechanism to adjust and cope with a variety of stimuli. Thus, stress is an important aspect of life and not inherently bad. However, it is useful to distinguish acute from chronic stress. Acute stress means that a stressor is a short-period event which an individual can tolerate or even benefit from. Chronic stress means that a stressor is a long-term event that the individual struggles to continually deal with. The latter as well as repetitive acute stress which does not allow for coping or recovery are essential for evaluating animal welfare (Wielebnowski 2003). It is important to understand that an animal's welfare state is located at a continuum between the extremes of very poor and very good and that at different times the individual's welfare can decline and improve. To what degree the level of discomfort is acceptable for an individual will depend on several factors and needs to be closely monitored by institutions and in open discussion with the EEP coordinator, other EEP species committee members and the TAG chair.

The assessment of animal welfare is neither straightforward nor simple. How can we then reliably assess an animal's negative and positive (subjective) experiences? The **Five Domains model** (Mellor & Beausoleil 2015) is a simple and useful framework for understanding systematic and structured assessments of animal welfare (Fig. 2). The model itself does not define what is good and bad welfare. It supports us in qualitatively grading welfare compromise and enhancement. The purpose of each domain is to direct our attention towards what is relevant to welfare assessments. Animal welfare assessments and management help us to monitor, detect and correct poor welfare when it occurs, and to maintain good welfare and preferably very good welfare when it is practically feasible. Importantly, the Five Domains model is subjected to continuous updates which, at each stage, incorporate modern verified scientific thinking relevant to animal welfare assessment (Fig. 3). Hence, the latest update of the model includes specific guidance on how to evaluate the various impacts of human behaviour on animal welfare and the potential it has to elicit welfare-enhancing positive effects or welfare-compromising negative effects (for more details cf. Mellor et al. 2020).

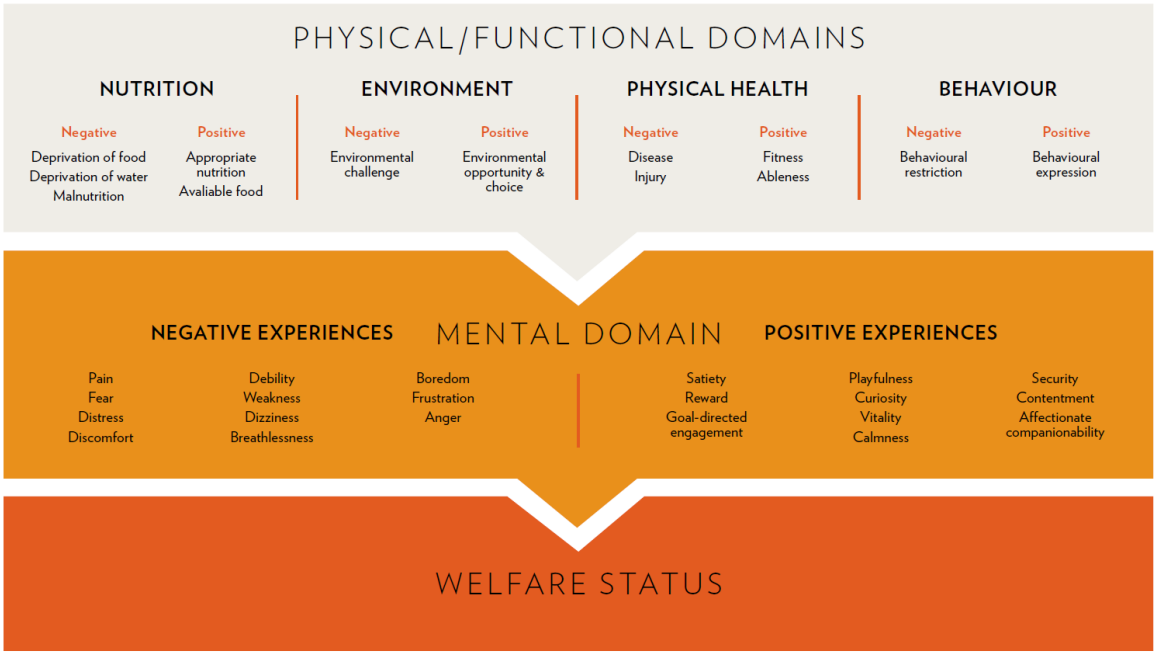

***Figure 2**: The Five Domains model for understanding animal welfare, divided into physical/functional and mental components, provides examples of how internal and external conditions give rise to negative (aversive) and positive (pleasant) subjective experiences, the integrated effects of which give rise to an animal's welfare status. (cf. WAZA Welfare Strategy 2015)*

Human-animal interactions likely to generate negative affects [examples]
Persons near animals that have had little or no prior human contact [*Animals:* rangeland, free-roaming and feral animals; wild-caught fish for display and other wildlife caught for use as pets.]
Persons whose presence adds to already threatening circumstances [*Wildlife managers:* trap-kill, trap-mark-release, capture-relocate; closely confined with no refuge; hands-on zoo visitor or tourist events. *Livestock handlers:* farmhands, transport drivers, sale yard staff, slaughterhouse workers. *Veterinary care teams:* veterinarians, veterinary nurses, animal attendants and owners.]
Persons whose current actions are directly unpleasant, threatening and/or noxious [*Actions:* psychological/physical abuse; serious mistreatment or neglect; physical restraint for aversive management or therapeutic procedures; aversive training methods; separation from dependently bonded companion animals; some veterinarians; riders whipping tired horses in sport.]
Persons whose prior actions are remembered as being aversive or noxious [*Persons:* intentionally cruel persons, unskilled trainers, unskilled animal handlers, stockpersons who apply routine noxious procedures, some researchers, some veterinarians, some farriers.]
Bonded humans whose actions cause unintended harm [*Actions:* affectionate displays seen as threatening by the animal; owners absent from bonded pets for long periods; owners delaying efficacious therapies; delayed end-of-life decisions for animals with compromised welfare.]
Human-animal interactions likely to generate positive affects [examples]
The companionable presence of persons who provide company and feelings of safety [*Persons:* Owners and/or caregivers whose animals are closely bonded to them, including companion, recreational, hobby farm, service, disability, breeder and other animals.]
Persons who provide preferred foods, tactile contacts and/or training reinforcements [*Persons:* companion animal owners, animal care staff; trainers using positive reinforcements; zoo staff using food enrichments.]
Persons participating in enjoyable routine activities [*Activities:* games, daily exercise, regular training.]
Persons participating in engagingly variable activities [*Activities:* diverse daily service functions, training schedules and/or opportunities for new experiences.]
The calming presence of familiar persons in threatening circumstances [*Actions:* hands-on gentling by persons strongly bonded to the animals.]
Persons acting to end periods of deprivation, inhibition or harm [*Activities:* delivering water, food, company and liberty from confinement.]

Figure 3: *The latest update of the Five Domains model helps us to understand how the interactions with humans may lead to negative or positive affective experiences in animals (cf. Mellor et al. 2020).*

A third major concept that is crucial in maintaining good welfare in captive animals, that also applies to gorillas/orangutans is the **24/7 across lifespan** animal welfare concept developed by Brando & Buchanan Smith (2017). As mentioned above, the welfare state of an animal is expected to vary at different stages of an animal's life. Thus, this welfare concept encourages us to consider the animal's **lifetime experience** (Fig. 4). To quote the authors:

"*Care staff spends a limited number of hours at a zoo, wildlife centre, or sanctuary. The animals however, are there 24/7, year-round for life unless they are part of a reintroduction program (or escape!). Indeed, the human working day dictates the care provided to captive animals. Husbandry activities typically occur during 6–8 daylight hours, which are not necessarily biologically relevant times for the animals. Care staff are not*

normally present to observe and provide for the needs and preferences of captive animals most of the time (i.e. 16–18 h/day). Given that animal care personnel are fundamental to promoting good welfare, we propose a tool for care staff to determine how well they are providing habitats that meet animals' needs".

Although gorillas/orangutans are diurnal animals, this concept is a holistic approach to animal welfare and is helping us to further optimise how we care for animals in our institutions. This animal welfare assessment tool is based upon 4 key principles (good feeding, good housing, good health, and appropriate behaviour) including 14 welfare criteria relevant to zoo animals. For more details, the authors present an illustrated example in their respective paper mentioned above. Additionally, for great apes the composition and dynamic of the social group in relation to a specific individual should also be considered. Special consideration should be given to aging animals as they may be particularly vulnerable to a number of negative welfare experiences including painful physical changes or medical conditions associated in relation to aging, frustration and/or aggression due to changing physical abilities, social difficulties or cognitive decline (Krebs et al. 2018).

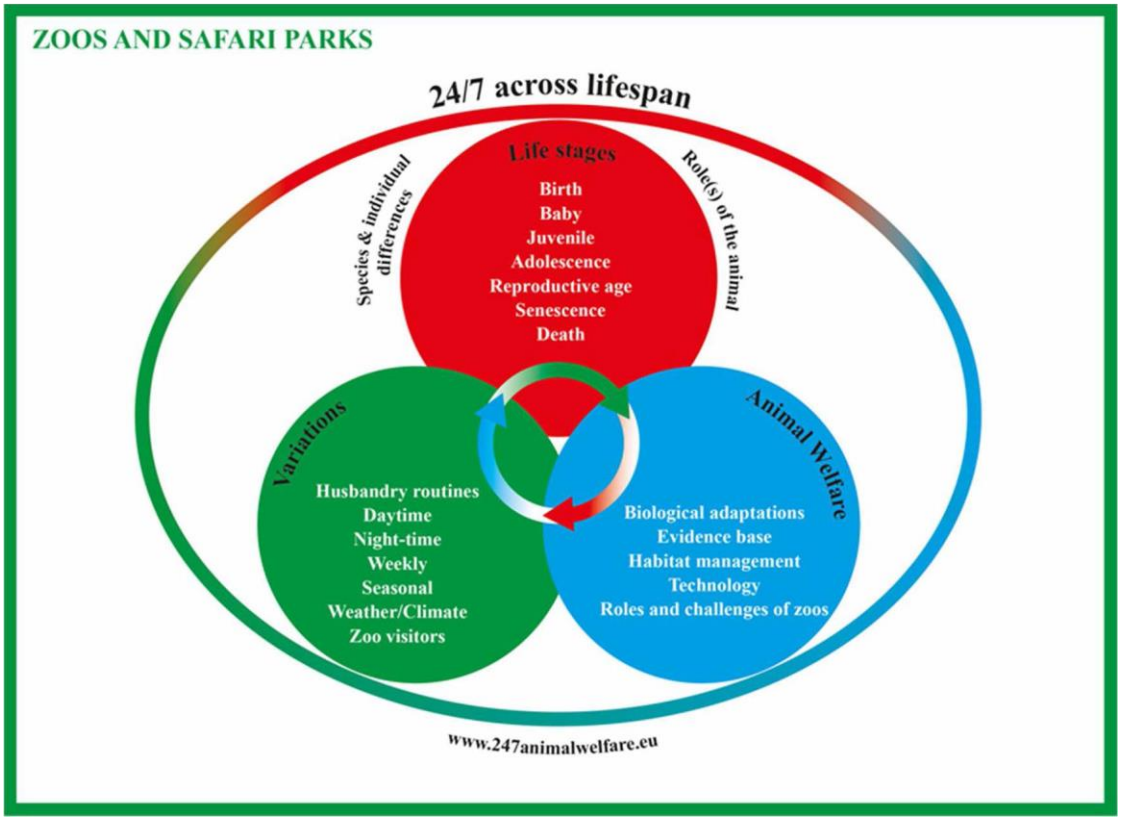

Figure 4: *Schematic overview of the 24/7 across lifespan welfare concept. It shows the different life stages and aspects that can influence an individual's life over time.*

The specifications given in the following chapters are under constant review in order to improve the management of gorillas and to promote new developments in this regard.

In sum, the different chapters cover quite well the different needs highlighted in the abovementioned welfare concepts. Nevertheless, with the growing scientific knowledge about great apes and animal welfare during the last few decades, modern zoos and aquariums are constantly improving the lives of animals in our care. As we learn more and more about animals and their needs – in the wild and in captivity – the concept of animal welfare will continue to evolve. A recent gorilla husbandry survey addressing basic – yet – important welfare parameters helped us to learn more from our holders about their current management practices and individual experiences related to welfare (cf. Summary of Gorilla EEP Husbandry Survey). By combining theoretical frameworks and our current practices we will have the best outcome in increasing the

welfare for our gorillas/orangutans. Committing to the WAZA Animal Welfare Strategy means that we proactively provide our gorillas/orangutans with rewarding challenges and choices leading to positive experiences.

Looking at the implementation of animal training across holders, there is still great potential for improvement. By investing more in advanced medical training, we can improve several domains of the Five Domains Model at the same time, namely physical health, behaviour, and mental state. We should take this opportunity to reduce stress in difficult management situations - for animals and the staff involved.

2.0.1 References (Welfare Commitment)

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2.0.2 Summary of the Gorilla EEP Husbandry Survey

55 (=71%) out of 78 holding institutions participated in the survey.

The presence of keepers (h/day) ranged between a minimum of 4 hours up to 13 hours a day. The average daily keeper presence is 8.5 hours which reflects the animal keeper working hours – at least in Switzerland.

Keepers check their animals on average 6 times a day. The majority of institutions reported that they check their animals multiple times a day (>10x/day) - if special management situations (i.e. pregnancies, introductions, sick animals etc.) arise even more. Furthermore, in most institutions keepers work within hearing distance and therefore can react if necessary. 3 institutions reported back that they work with CCTV cameras.

Number of feedings per day range between 2 up to 8-9 times a day. On average, institutions provide 5 feedings per day. 29 institutions (53%) reported to provide browse/alfalfa to their gorillas. Some institutions are freezing their browse to be able to provide browse all year around (15 institutions, 27%). A small number of institutions is using automatic feeders (6 institutions, 11%).

Observation time/animal/day varies a lot between institutions. The average showed that institutions spend 15min to observe their individual gorillas. 10 institutions (18%) reported that they spend between 20-30min observing their individuals. The responses to this parameter remain difficult to interpret because it was not always clear whether observation time was indeed indicated per individual as asked for or for the entire group.

18 institutions (32%) reported that they do not train their animals (Fig. 1). 22 institutions (39%) reported that they do basic training. This training mostly includes basic behaviours like for example “showing body parts”, “trading” and “shifting”. 16 institutions (29%) invest in advanced medical training involving hand injections and/or voluntary blood draws. Training time/animal/day ranges between 5-10min. Based on experience from our own institution, this training time corresponds well with the short attention span of great apes. The number of keepers training the animals ranged between 1 and 7 keepers. New behaviours are typically established by a single trainer. Established behaviours are then trained by other keepers as well. Depending on the complexity of the behaviour being trained 1-3 keepers can be necessary.

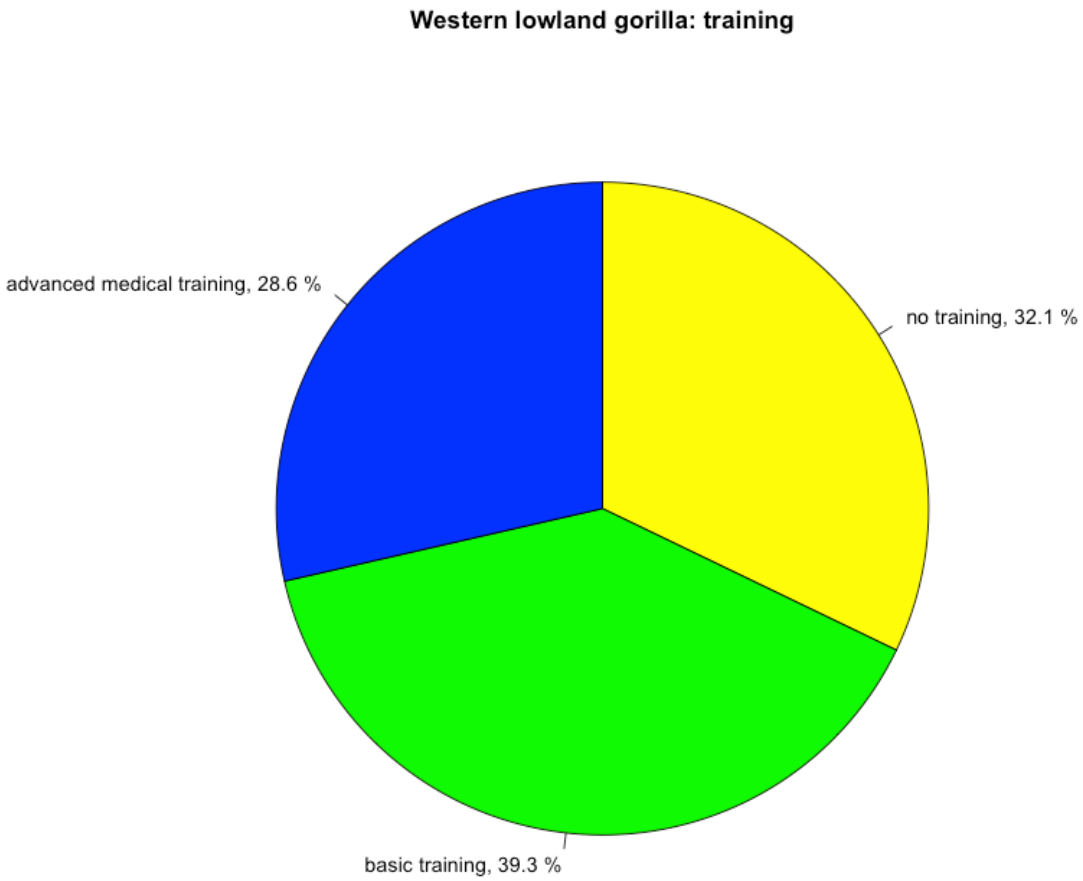


Fig. 1: *Training: 32.1% (18 institutions) do not train, 39.3% (22 institutions) invest in basic training and 28.6% (16 institutions) invest in advanced medical training.*

All institutions are enriching their animals with a variety of different objects. Most institutions reported that they exchange the enrichment objects daily. Some institutions have their gorillas in a mixed-species exhibit. These inter-species interactions add to the overall enrichment as they can be regarded as social enrichment. With an exception - all institutions reported that they regularly provide some sort of bedding material (e.g. straw, wood wool, blankets, hammocks) to their animals – day and night (Fig. 2&3).

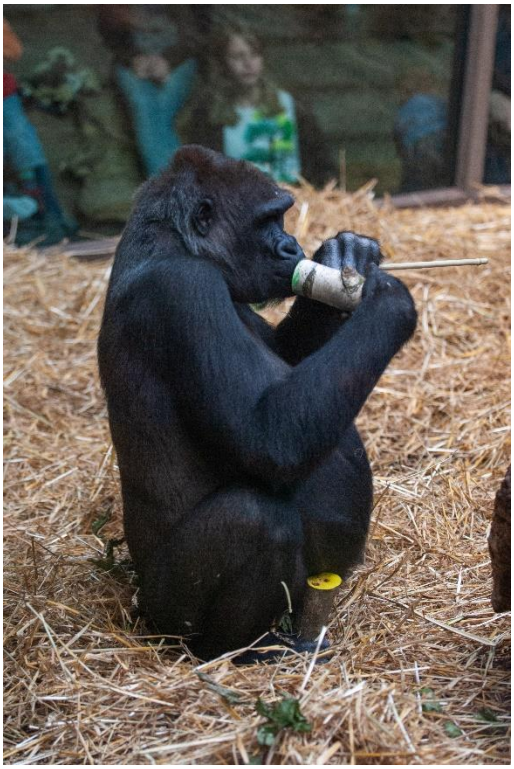


Fig. 2&3: *Nest building, browsing and object enrichment in gorillas at Zoo Zurich.*

On average, institutions allow their animals to have access to their outside enclosures for 9 hours a day - from spring until autumn (Fig. 4). 26 institutions (46%) reported that they give their animals 24h access to their outside enclosures.

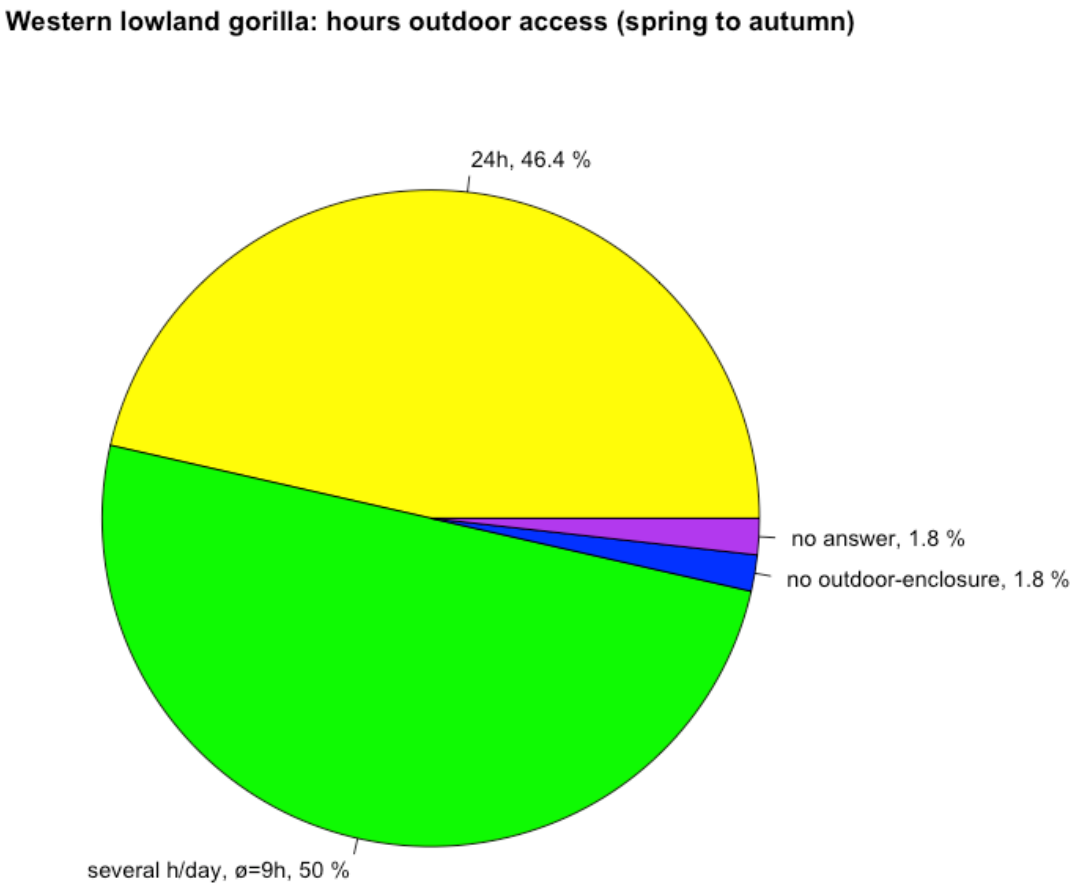


Fig. 4: *Outdoor access: 46.4% (26 institutions) provide 24h access to the outdoor enclosure, 50% (28 institutions) provide access for several hours a day with an average of 9h/day, 1.8% (1 institution) do not have an outdoor enclosure and 1.8% (1 institution) did not answer this question.*

The minimum temperature at which animals are allowed to go outside varied considerably between institutions – probably also because climate conditions are different between regions (Fig. 5). A few institutions let their animals play in the snow for a limited amount of time (Fig. 6&7). Water moats restrict access to outdoors in winter because of safety reasons.

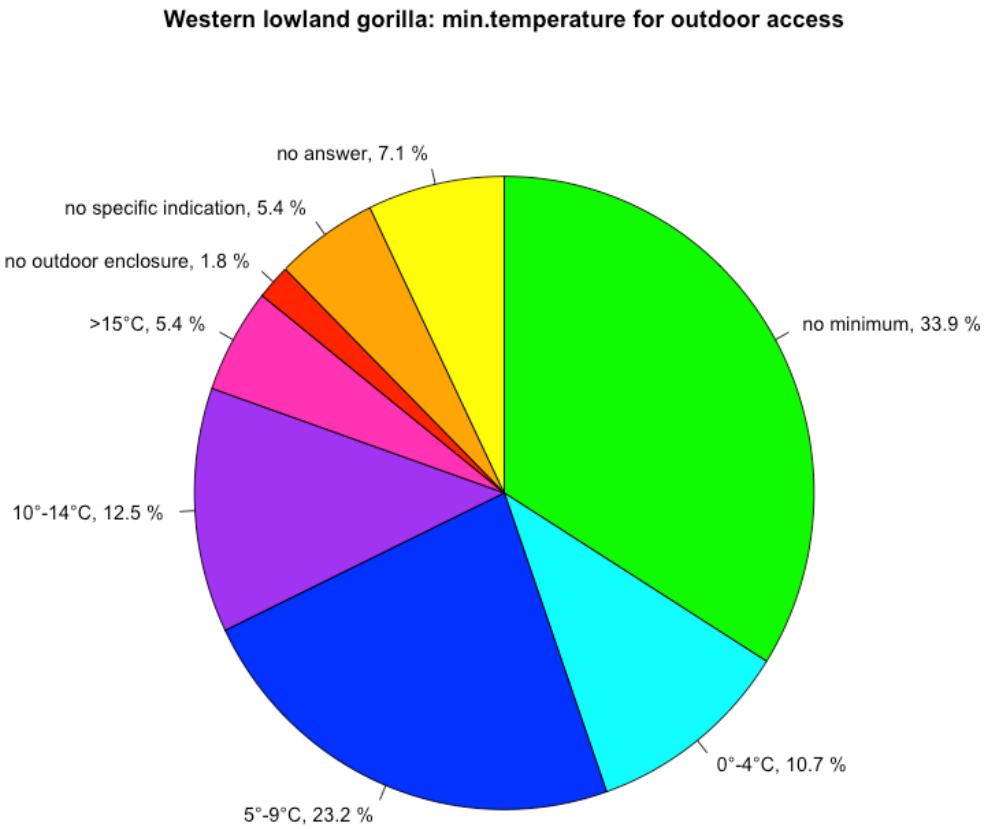


Fig. 5: *Minimum temperature for outdoor access: 33.9% (19 institutions) do not have a minimum temperature, 10.7% (6 institutions) let their animals outside between 0-4°C, 23.2% (13 institutions) let their animals outside between 5-9°C, 12.5% (7 institutions) let their animals outside between 10-14°C, 5.4% (3 institutions) indicate the minimum temperature at 15°C or above, 1.8% (1 institution) do not have an outdoor enclosure, 5.4% (3 institutions) gave no indication of a specific temperature and 7.1% (4 institutions) did not answer this question*.

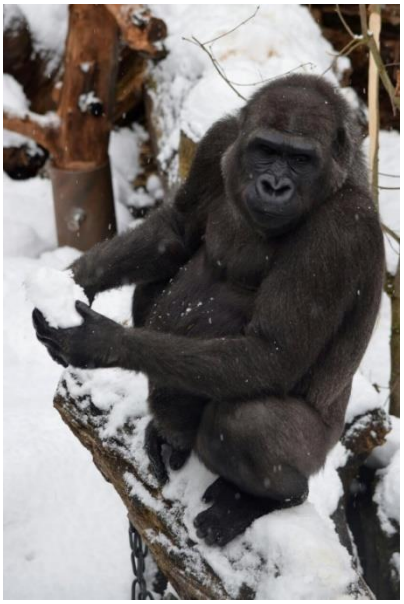


Fig. 6&7: Gorillas playing in the snow at Zoo Zurich.

2.1 Enclosure

2.1.1 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.

2.1.1.1 "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.

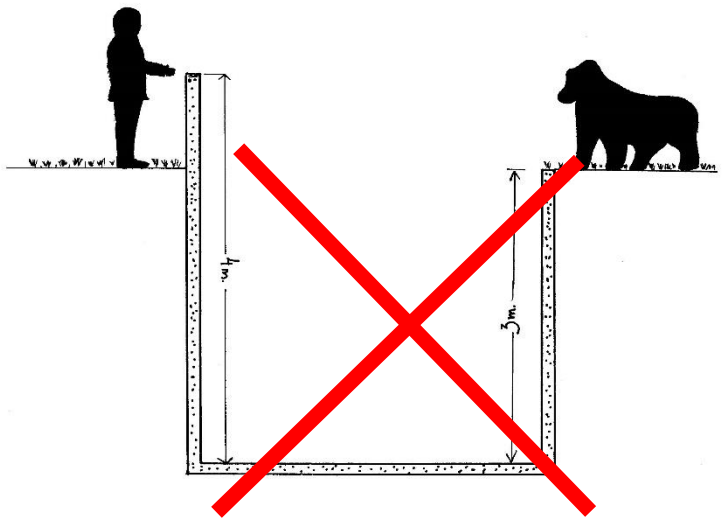


Fig. 2

2.1.1.2. "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.

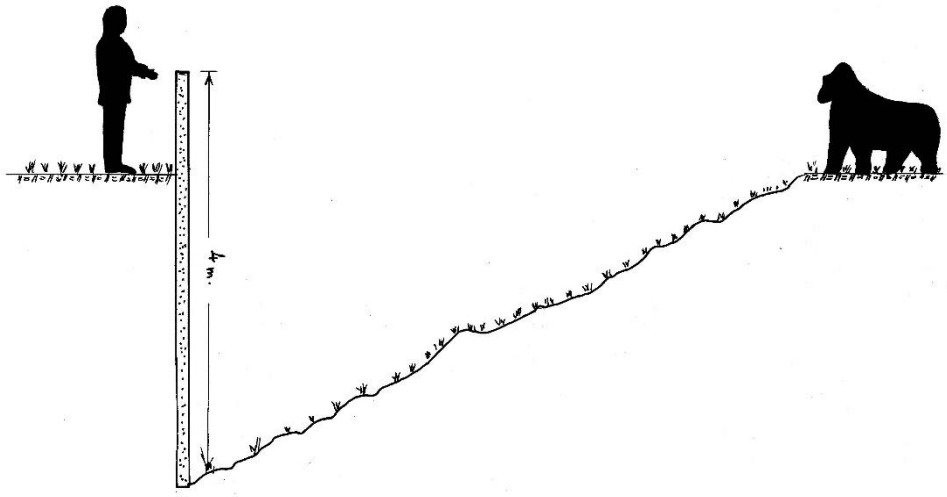


Fig. 3

2.1.1.3 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 behaviour 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 behaviour 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 (or as near to as possible) 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 should be noted that for a moat dividing two animal islands the moat needs to be wider than 7m (i.e. 9-10m) in order to ensure an acceptable profile from both sides and hence the safety of the animals.

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 slip 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.

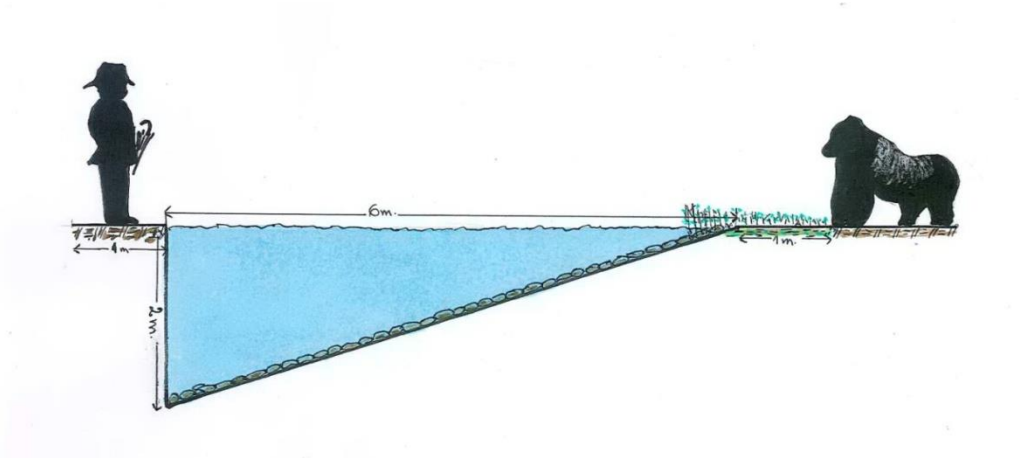


Fig 4

2.1.1.4 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.

2.1.1.5 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.

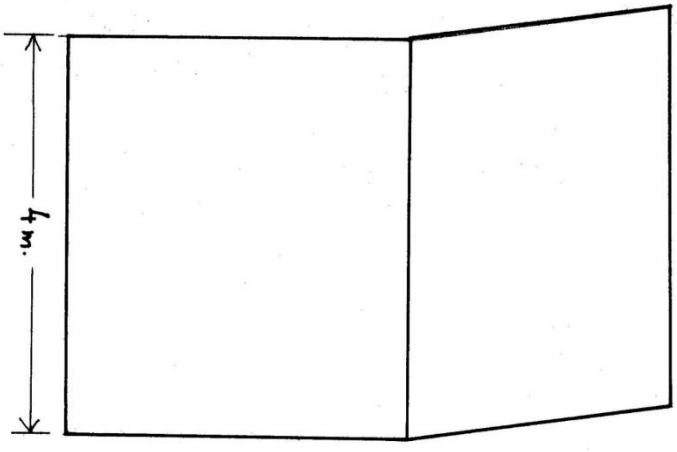


Fig. 5a

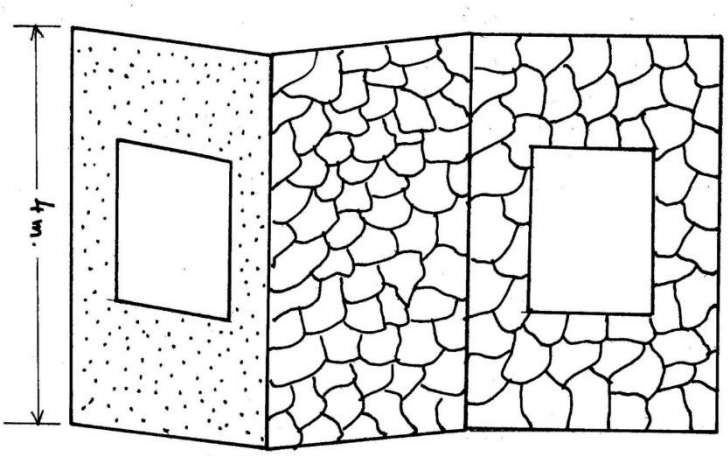


Fig.5b

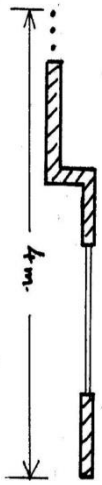


Fig. 5c

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

2.1.1.6 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.

2.1.1.7 Physical characteristics of the mesh

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, centre distance 30-56 mm, distance between transversal bars (flattened steel or rectangular tubes) 440-700mm.**(see Fig. 6e)**

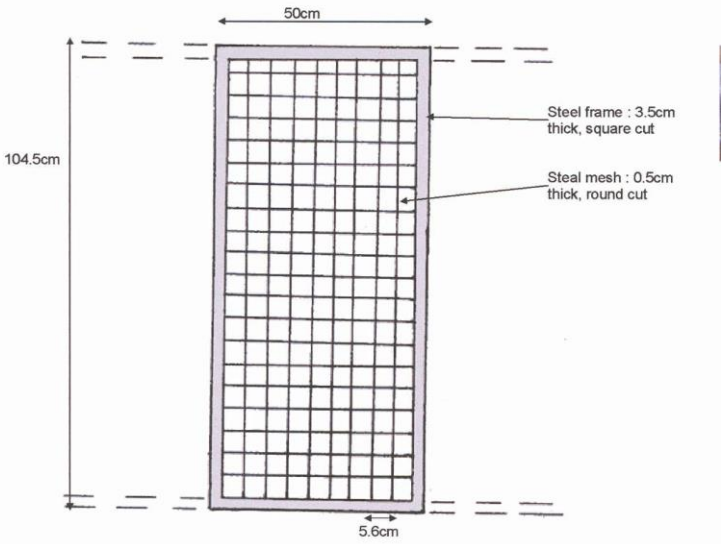
Fig. 6a

Gorilla mesh - La Vallée des Singes

The mesh is made of a series of contiguous steal frames that are fixed to the walls (rectangular ones for small hights and square ones for larger hights . A continuous steal mesh screen is welded over these frames.

Rectangular frames

Square frames



Mesh welding to frame (terminal)

Mesh welding to frame (intermediary)

Fig. 6b

Fig. 6c 

Fig. 6d 

Fig. 6e 

2.1.1.8 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.

2.1.1.9 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 their display. 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 are more visual barriers in place than are generally used.

See section on containment barriers (7.3.2.) for outside exhibits. Steel barriers should be non-corrosive (stainless steel, or hot dip) 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 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.

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 complex variety 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.

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 the EEP Coordinator for the results of the Great Ape TAG biofloor survey.

The main conclusions from that survey are listed below.

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 with permeable matting layer (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!
- Use biodegradable detergents for cleaning

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.)

2.1.3 Furnishings and Maintenance

2.1.3.1 Furnishings

For gorillas, environmental 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.

Physical complexity includes not only the well-designed topography and the landscape, but also good furnishing as well. In a good, naturalistic outside enclosure use of primarily natural materials is recommended such 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.

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 achieved 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.

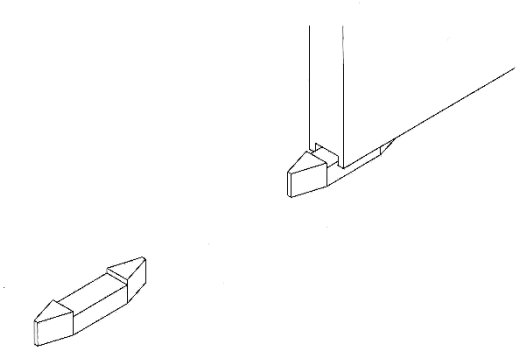
2.1.3.2 Maintenance

2.1.3.2.1 Doors and service access to the enclosures

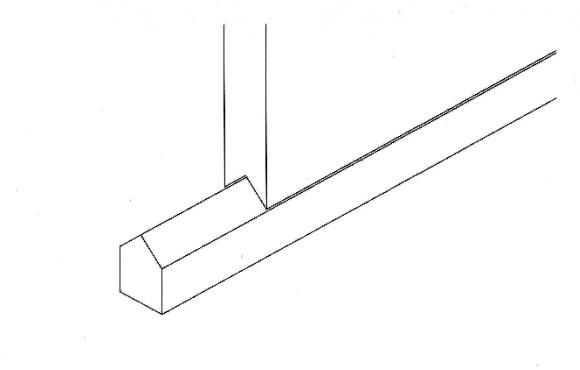
Doors between enclosures should all have an extra security mechanism to prevent gorillas from opening the doors themselves. In designing the mechanism for opening the doors between enclosures, it should be kept in mind that gorillas might move the door with great force while a keeper is opening or closing 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).



(drawing 1 - Sliding door with torpedo guides)



(drawing 2 - 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 where practicable.

Doors should be self- locking (slam lock) (Fig. 1)

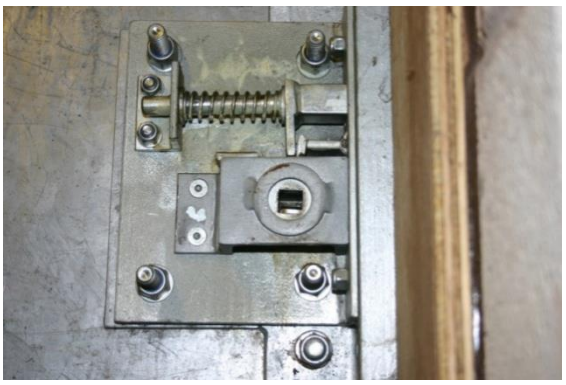


Fig.1 Self-locking doors

2.1.3.2.2 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 no.34 for adults and no. 33 for young gorillas)

2.1.4 Environment

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.

2.1.4.1 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.

2.1.4.2 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.

2.1.4.3 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.

2.1.4.4 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.

2.1.5 Dimensions

2.1.5.1 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.

2.1.5.2 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.

2.1.5.3 Indoor accommodation

2.1.5.3.1 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 orevent 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.

2.1.5.3.2 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.

2.1.5.4 Outside exhibits

2.1.5.4.1 Landscape, topography and vegetation

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.

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.**

2.1.5.4.2 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 the public. Hiding places also should be set up preferably so that they cannot be monopolised by high-ranking animals.

2.1.5.4.3 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.

2.1.5.4.4 Outside separation enclosure

Just like for the inside enclosure, 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.

2.1.5.5 Observation facilities

The keepers should be able to easily observe the gorillas in any part of the inside areas. This can be achieved 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.

2.1.5.6 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.

2.1.5.7 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 which can be used as one, but have the flexibility to be divided. 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 not be in visual, olfactory or auditory contact with an enclosure of a breeding group. Whilst it is difficult to completely prevent olfactory or auditory contact it is of greatest importance to be able to prevent visual contact between separated individuals (be it in a bachelor or family group situation) or between groups as this can definitely lead to stressful interactions. This applies both to outdoors and indoors whereby a solid wall is arguably the best barrier in such instances.

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 indispensable.

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.

2.1.6 References (Enclosure)

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2.2 Feeding - Gorilla Nutrition

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 common in zoo individuals with an estimated 60 % of the AZA population regularly exhibiting this behaviour (Tennant et al. 2021). It has never been reported from wild populations. 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). This morphology is typical for a species adapted to a very fibrous diet. This is further reinforced by recent literature on the gorilla gut microbiome. Gorilla microbiome largely consists of Bacteroidetes and reduced Firmicutes which has been associated with a highly efficient fibre digestion capacity (Gomez et al. 2015).

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	50	69	NA	NA	NA	NA	Campo,	

(*Gorilla gorilla gorilla*)							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)
	96	106	44	89 %	yes	Yes (weaver ants)	Mondika, Republic of Congo	Lodwick and Salmi (2019)

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

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).

2.2.3.2.1 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).

2.2.3.2.2 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 gorilla differs 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; Lodwick and Salmi, 2019). 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.

Estimated Nutrient Intakes

A recent field study has estimated the nutrient intake of the Mondika Western lowland gorilla population (Lodwick and Salmi, 2019). The yearly nutrient intake has been averaged to be (on a dry matter basis) crude protein: 11.9 %, total non-structural carbohydrates: 33.5 %, neutral detergent fibre: 53.9 %, hemi cellulose 17.5 % and cellulose: 19.4%. This confirms the assumptions made based on feeding ecology and digestive morphology that Western lowland gorillas have a high fibre diet. The proportion of NDF and TNC are inverse and seasonally dependent which means during fruiting seasons, TNC will increase from 15 % of the diet to up to 50 % and NDF will decrease from around 70 % of the diet down to 47.5 %. This solidifies the fact that gorillas always have a high fibre diet.

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.

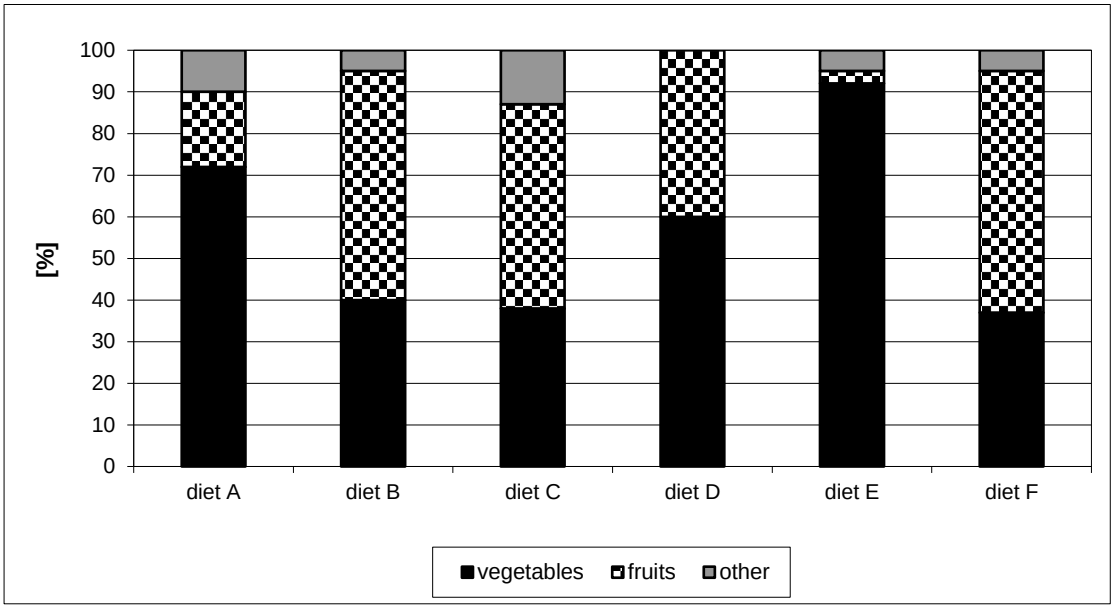

Figure 7. Gorilla diets from six different European zoos. Percentage of vegetables, fruits and others (meat, egg, milk, yoghurt, commercial products for human or non-human primates etc.).Modified from Hampe, 1999.

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 (which are rare in fruits cultivated for human consumption). 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.

2.2.4.2.3 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, 50% vegetables, 30% browse, and no more than 15% dry high-fibre primate biscuits and up to 5% of enrichment and training food items. If more pellets are necessary to reach adequate micronutrient concentrations, perhaps it would be wise to seek out a more appropriate pellet or increase the browse component of the diet.

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
Collards	Celery	Pumpkin
Kale	Corn	Sweet potato

Lettuce (any sort)	Cucumber	Turnips
Spring greens	Fennel	Jerus. Artichoke
Spinach	Leeks	Mangols
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 2.5

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; Tennant et al., 2021). Regurgitation and re-ingestion consist 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).

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2.3. Social Structure - Gorilla Behavior and Social Organization

2.3.1 Basic social structure

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 gorilla troop size recommended in EAZA breeding groups 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).

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 some bachelor groups have been established where the males stay for some years until being tharsferred as silverback for a breeding group or stay for its life leading this kind of groups.

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).

2.3.2. Changing group structure

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 riskiest 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.

2.3.2.1 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.
- It is recommended that the new gorilla be given an opportunity to explore the exhibit where the introduction will take place, before to the actual introduction process. This allows the new gorila to become familiar with escape routes in case stress or aggression become a problem as the introduction proceeds.
- Individuals that are not used to designs such as water moats and/or electric fences should be monitored when they explore the outside enclosure for the first time.

2) Habituation of the individual to the resident group

- 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).

- It is recommended that gorillas be given visual access to on another prior to introductions 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.

- 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).

- This may be necessary for only a few hours or up to several days depending on the age, sex, and psychological condition of the individual being introduced and the reaction of the group.

- If you observe affiliative response from one member of the group, it is worth to separate this one from the group to be used as introducer of the new one, but you need to allow this group member to join its group during part of the day to keep its rank and relationships.

- Create a balanced situation between resident group and individual to be introduced.

- Offer similar overnight arrangement.

3) Allow full physical contact between animals that show positive reactions.

It is better to introduce one to one animal for a few days until you observe both animals are calm and closer, if not working properly then try better with another member of the group that shows tolerance to the new animal. When both calm and closer you should try to continue adding other members of the group.

For new females it is important to get the support of the male, and to introduce the new female alone to the male could favour that she gets later his protection.

If introducing a new male, sometimes it is better first to associate him with each female alone until they are calm and relax, and afterwards to increase the number of females avoiding possible female coalition against him.

Keep the introduction processes with animals 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, the resident animal shoul be back in the group and in a calm atmosphere it is very important to let the new individual stay in visual contact with the rest of the group.

Provide 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.

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!

The introduction process should be **closely monitored** to determine when each step should be taken. The gorillas should be closely watched for signs of stress, and their physical and psychological status assessed at each stage of the introduction process. The process should be addressed following the animals' reactions.

Depending on background of the individuals, the size and the complexity of relationships within the group, and facility design, introducing new individuals **to the whole group in a more or less gradual introduction** can be recommendable. Especially in more complex groups, or when introducing a male into an existing group, a more stepwise introduction may be preferred. If aggression from a resident gorilla to the newcomer persists, it has been helpful in some cases to have these two individuals introduced to each other separate from the rest of the group to create a bond after which the two of them can be reintroduced back into the group

It is recommended to give the gorillas **maximum space** during an introduction, and avoid dead corners where animals can be entrapped. It is not recommended to do the initial introductions in outside enclosures, where usually there is less control over the animals, and observations may be harder. Therefore, it is adviced do an introduction in the inside enclosure and/or in the holding facilities, where interventions are more easy; but as soon as it is observed that there is not any intention of physical aggression the animal can have access to the outside enclosure, getting more space and reducing possible tensions. The presence of large amounts of food during an introduction can be helpful in creating a relaxed atmosphere, but sometimes this leads to tensions.

Much depends also on the character of the individuals, and on the kind of food that is offered. Offering (only) low quality food and/or food that is difficult to monopolise, such as browse, scattered seeds, non-preferred vegetables may provide distraction to the animals. Offering very valuable food, such as large pieces of preferred fruits, and/or food or enrichment items that can be easily monopolised can create extra tension and should be avoided during the first phases of the introduction.

2.3.2.2 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.

2.3.2.3 Important remarks/advice

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 four 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 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.

2.3.4 Sharing enclosure 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

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.

2.4.1 Mating

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.

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.

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).

2.4.2 Contraception

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.

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

Last Updated: March 2014

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 Deslorelindatasheetforde tailed 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

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.

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.

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.

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.

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.

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.

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.

2.4.3 Pregnancy

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.

2.4.4 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). Sexing a gorilla is not an easy task, for help look at the document *"Sexing an infant gorilla"* in the EAZA web (Holtkötter, 2018).

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 assisted-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 assisted-rearing techniques have improved substantially in recent years, assisted-reared gorillas still face many social problems. For that reason assisted-rearing should be avoided if at all possible.

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). Assisted-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.

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. Female maternal competence is influenced by the way she was reared herself, mother-reared or assisted-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,2006).

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.
In the case of a potential maternal neglect, institutions should contact the EEP coordinator and/or other experienced members of the gorilla species committee. They will help them find the best solution as to decide if assisted-rearing is unavoidable, if early (re-)introduction of the infant to the mother or a foster makes sense.

2.4.5 Development and care of the young

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.

To avoid assisted 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 assisted-rear an infant. Moreover, the infant’s long term future should be taken into consideration before finally deciding to assisted-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 of management, 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 (see EAZA Culling https://www.eaza.net/assets/Uploads/Governing-documents/EAZA-Population-Management-Manual-V4.2.pdf 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.

2.4.5.1 Infant development and parental behaviour

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.

2.4.5.2 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.

2.4.5.3 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)

2.4.5.4 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).

2.4.5.5 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.

2.4.5.6 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.

2.4.5.7 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).

2.4.5.8 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.

2.4.5.9 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).

2.4.5.10 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).

2.4.5.11 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.

2.4.5.12 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).

2.4.5.13 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.

2.4.5.14 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.

2.4.5.15 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.

2.4.6 Assisted rearing and early (re-)introduction

In any case before deciding to Assist rearing an infant, to contact the coordinator is mandatory. If such would be the case, the coordinator and the species committee members will facilitate their knowledge, expertise and advice to ensure the best future for the assisted-reared individual.

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).

Contact or socialisation with conspecifics is recommended as earlier as possible, even better with adult conspecifics, as it is important to prepare the infant for the integration into a family group. The transfer of the infant to another institution should be done within the first month of life, but at the latest before the infant reaches 2 months old.

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

Early reintroduction of an assisted-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 12 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 assisted-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 available.

2.4.6.1 Physical needs of assisted-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 was 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.

Assisted-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.).

2.4.6.2 Psychological and social needs of assisted-reared infants

Before a hand-reared gorilla can be placed with conspecifics/peers (which should happen as soon as possible), human contact could be 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).

Assisted-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 assisted-reared female's chance of successful breeding (Beck & Power, 1988).

Sometimes, assisted-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 assisted-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"

2.4.6.3 Exposure and introduction to adults

An assisted-reared infant will either be (re-)introduced to the mother or a foster (depending on factors listed in above) at an early age (3 months at the latest) or it will be transferred to another institution in a n earlier stage. Infants stayed at the EEP Wilhelma nursery until they reach the age of 3 years in the past. Nowadays, If some infant would need to go to the integrated nursery of Stuttgart's new ape house, infants will be in (at least) visual, olfactory and auditory contact to the gorilla family group right from their arrival, and it could 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 the Whilhelma group. So that, the EEP should 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 assisted-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 assisted-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.

2.4.7 Gorilla EEP Population Management

2.4.7.1 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. Since then, much progress has been made on the management of captive gorillas, and caution had to be taken to not exceed the carrying (holding) capacity of the involved institutions in the EEP.

Currently (as of Dec 31, 2021), 77 institutions formally participate in the EEP. This includes 60 EAZA and three non-EAZA members in the European region. Moreover, the EEP includes five Asian, five Australian, two South African, one South American and one institution in the Middle East. Now many more institutions especially in Australasia are keeping gorillas that have been born in this own region or arrived there through the EEP. These are now considered an autonomous population that is increasingly self-sustainable and managed under the Zoo and Aquarium Association (ZAA) in Australasia. These are nevertheless still managed in collaboration with the EEP and some exchange of animals in the coming decades is likely needed.

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

Materials and Methods
Data of the European gorilla population was obtained from the International studbook (Linn and Bender, 2022) using ZIMS for studbooks, and analysed with PMx (Ballou *et al*.2022)

2.4.7.2 Development of the Population

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

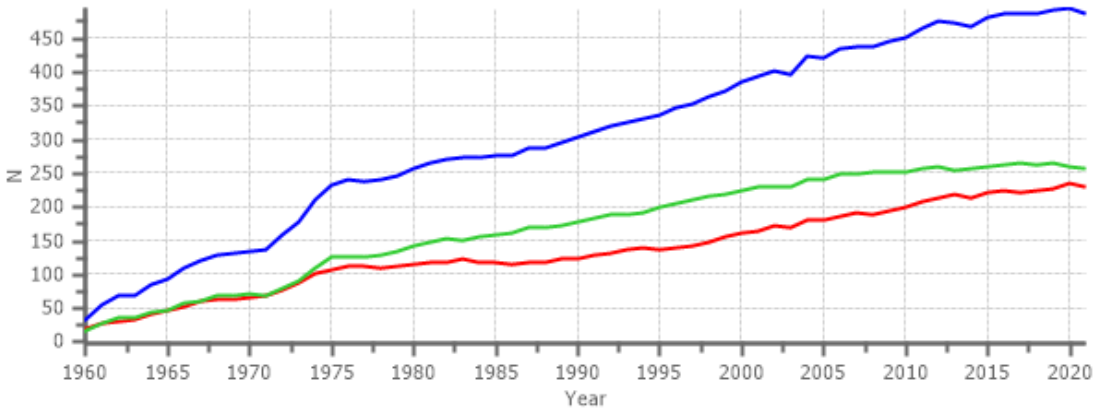

Figure 1: ***Development of the EEP population 1960-2021: Total number, Males , Females***

The EEP population consists of 485 (228.257.0) at 77 institutions (Dec 31, 2021). This number can be broken down as follows:

- European region: 194.234 (428) in 63 institutions*
- Asian subregion: 13.5 (18) in 5 institutions

- Australian subregion: 11.10 (21) in 5 institutions
- Middle East subregion: 1.5 (6) in 1 institution
- South African subregion: 5.0 (5) in 2 institutions
- South American subregion: 4.3 (7) in 1 institution

* including 9.0 in 3 non EAZA institutions – Amnéville, Fasano, Kiev (EAZA CfM)

The population size has grown steadily in the last decades until 2012, when the population growth has slowed down due to a planned reduction in the birth rate and transfers out of the EEP. Nevertheless, there has not yet been a single year with more deaths than births (figure 2). While only 30 years ago, there were still more wild-born individuals in the population than gorilla born in human care, now only 8% of the population is wild born, which are mostly males above 40 years old. (figure 3).

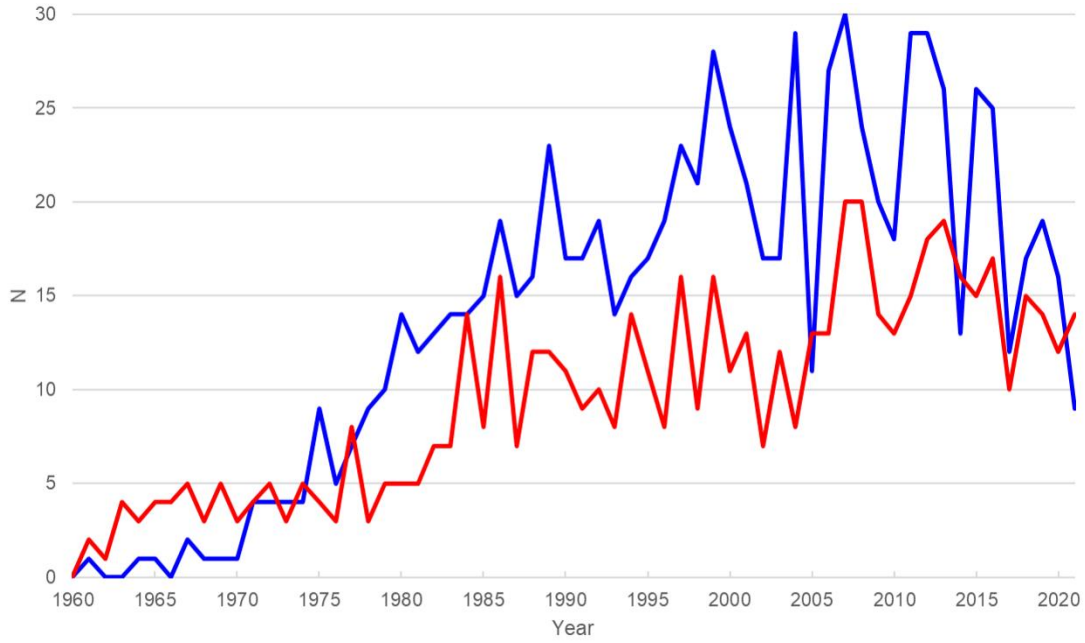

Figure 2: The number of births and deaths in the EEP population 1960-2021: Births, Deaths.

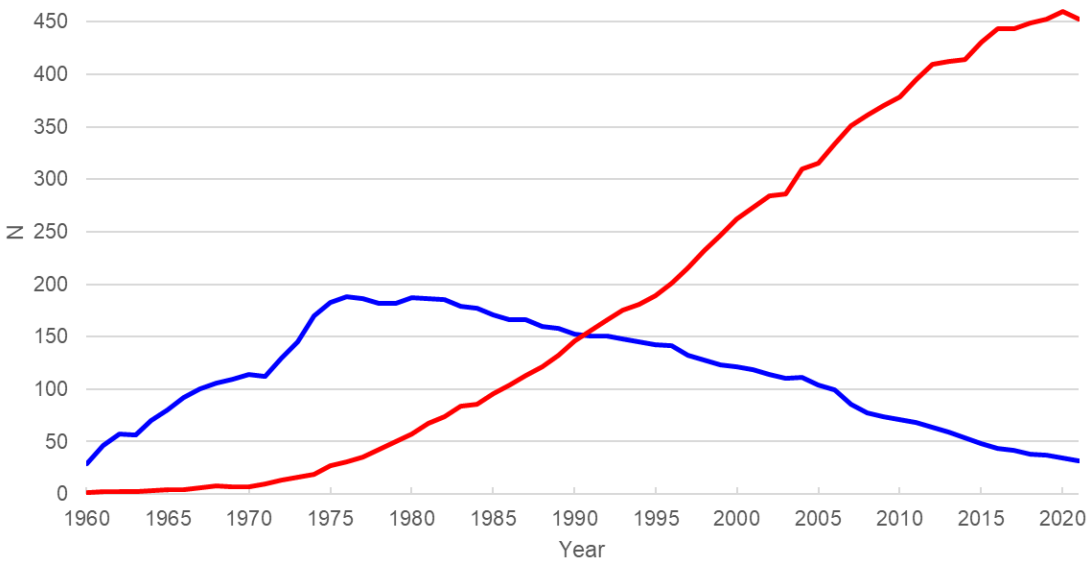

Figure 3: Ratio between wild and captive born animals in the EEP population 1960-2021: Wild born, Captive born.

2.4.7.3 Reproduction

The earliest observed reproduction of males is around 3.5 years, of females around the age of six years. Female fecundity has historically developed as following (figure 4):

- Fecundity peaks from 8 to 27 years
- After the age of 27 years, fecundity decreases continuously.
- Between 27 and 35 years, fecundity is roughly half of the reproductive peak.
- Between 35 and 45, fecundity is roughly a quarter of the reproductive peak.
- After the age of 40, reproduction becomes very rare and has not been observed in females older than 42 years old. Please note that only 40 females have lived beyond this age, which means that the sample size is limited.

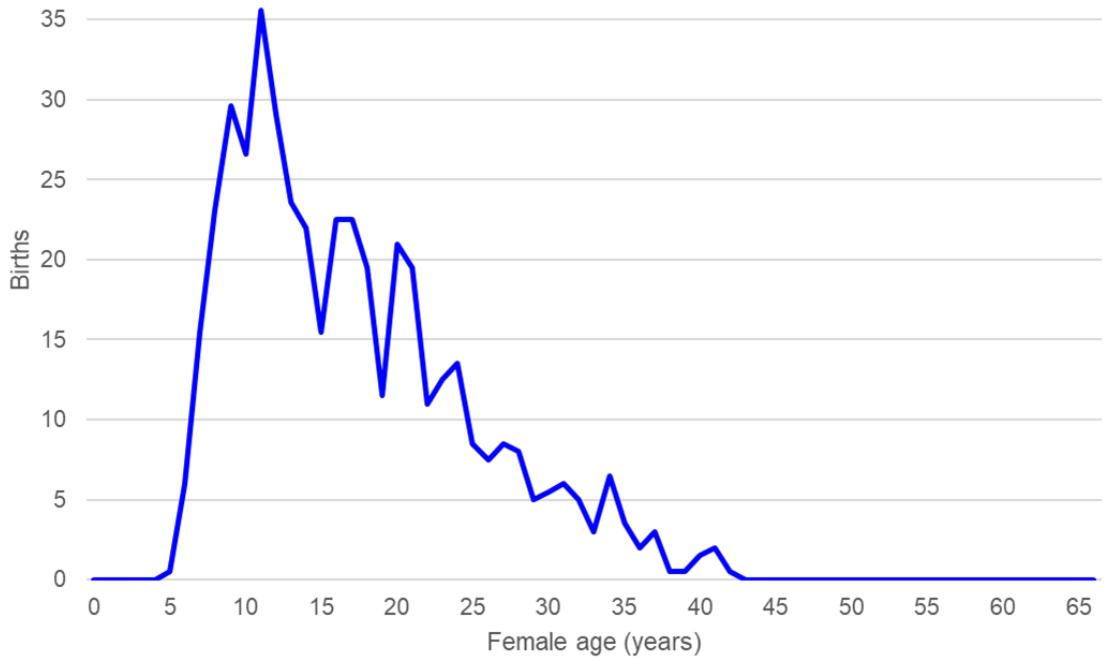

Figure 4: Births counts for female age classes.

There has so far been little reproduction observed in males above 40 years, but this is also because generally very few males have lived beyond this age (N= 20) and those that have, either never or hardly reproduced at younger ages. It still needs to be determined why these males generally bred this little and whether this is related to the old age they achieved.

First year mortality has been observed to be 24% (N=354) for both males and females. The observed mortality rates for males and females have been summarised in Table 2. Relatively, mortality is low and comparable for males and females until around the age of 32-33 years. However, from this age onwards, mortality becomes relatively high for both sexes, and male mortality is almost twice as high as female mortality. Female mortality then increases again considerably from the age of 41 years (figure 5). For males, there is not sufficient data to draw any conclusions about a further increase, although the available and very limited data does suggest a doubling of the mortality rates. Note that there are indications that male

mortality rates above the age of 32 are decreasing over time (which could happen through e.g. husbandry changes). It will take at least 10 years still before there is enough data to draw any conclusions on this.

Of the individuals that survive their first year, around a third of the females reach the age of 47 and older and a third of the males reach the age of 42 years and older. A quarter of the females is expected to reach the age of 50 and several females in the International studbook have lived into their sixties. That includes at least one individual born in human care as well as wild-born individuals with estimated birth dates that have lived over 60 years within a zoological setting

Females	
Age classes (years)	Annual mortality observed
1-25	1.0% annually (minimum N= 103)
24-33	2.3% (minimum N= 92)
33 to 41	3.7% annually (minimum N= 59)
41 to 48	7% (N ranging from 53 to 25 individuals)
Males	
Age classes (years)	Annual mortality observed
1-21	0.9% (minimum N= 82)
21-32	1.8% (minimum N= 51).
32 to 41	7% (N ranging from 48 to 20)

Table 2: Annual mortality rates of females and males.

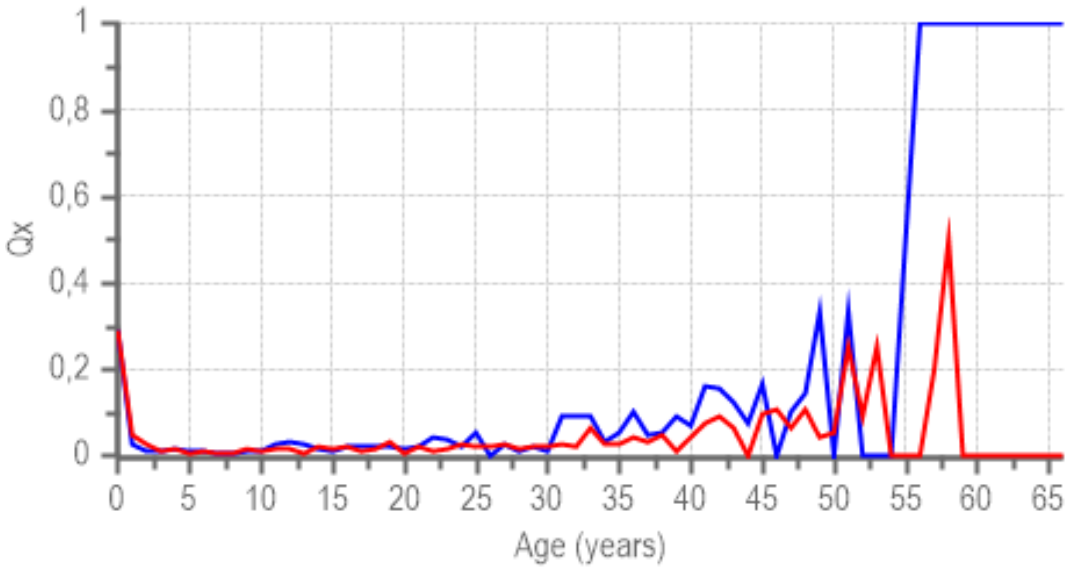

Figure 5: Mortality rates (Qx) of males and females: Males , Females

The population is demographically very robust, with a very large number of younger females and reasonably high fecundity. However, the reproductive potential of the population may decrease over time:

- The population will no longer grow as it has done in the past because the GEEP policy of applying contraception to avoid welfare problems resulting from reaching holding capacity and also does not need to grow any further to reach its goals. As a result, it is expected that with less breeding, females gain less breeding experience, although this will be mitigated as much as possible by strategically assigning breeding recommendations.
- Also, the population is still reasonably young, although the average age of females has already increased considerably compared to the past. This aging process will likely continue gradually over the coming 30 years after which the population will slowly start becoming younger again.

- Moreover, the proportion of females in the population will likely decrease as discussed below.

With the information currently available, the reproductive potential may reach an all-time low in 20-30 years. If this is not carefully monitored and managed, this may lead to an uncontrolled dip in the population size. However, this risk seems relatively low, and if there is any dip in population size, this is likely a small one (e.g. 10 individuals) unless the birth rate is drastically decreased. In any case, the population is expected to bounce back again.

The age-sex pyramid shows that the population is demographically very robust.

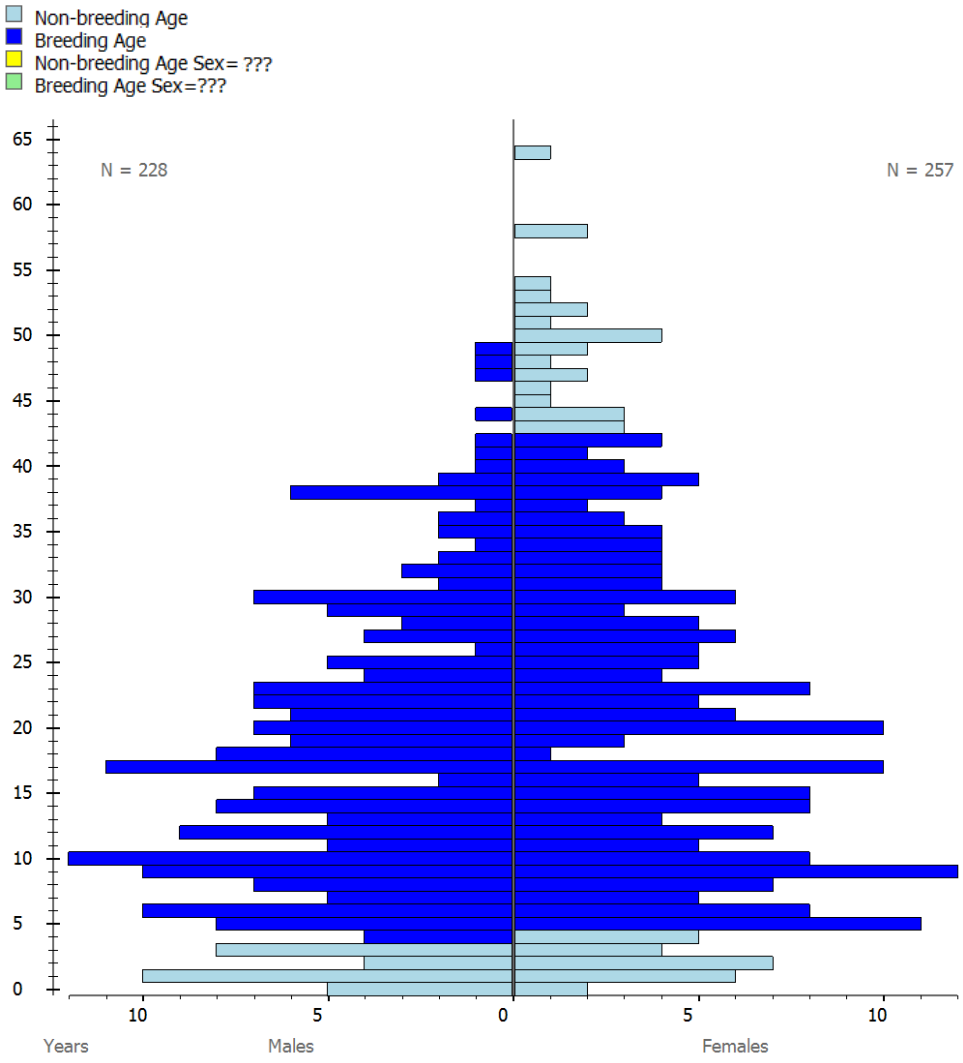

Figure 6: Age-Sex pyramid Dec 31, 2021.

With the increased breeding success, also the rearing type shifted significantly towards parent reared. The cases in which hand rearing were necessary decreased considerably over the years (figure 7). This trend is seen as a positive sign as the Gorilla EEP is favouring parent rearing, and if needed, foster rearing with early re-integration into a group.

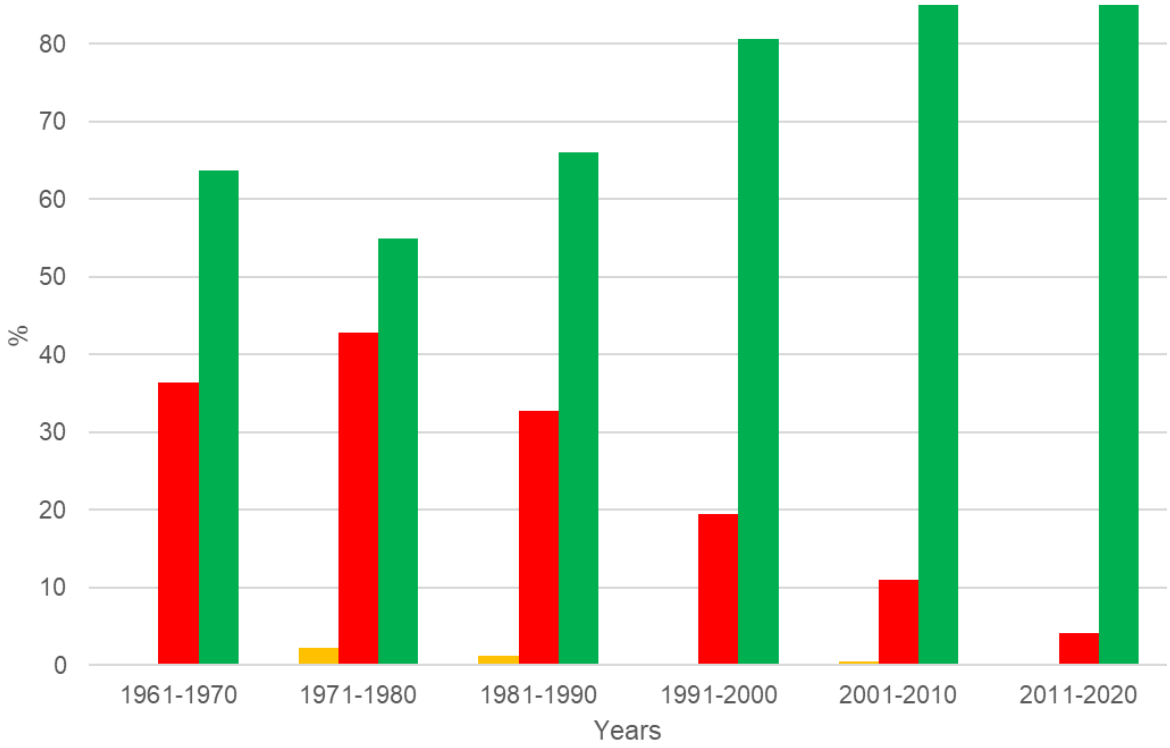

Figure 7: Rearing type rates in the past six decades (based on ZIMS for studbooks data): Hand, Parent, Foster.

2.4.7.4 Genetic analysis

The Western lowland gorilla EEP population is genetically very healthy. A total of 93 founders have contributed to the population, resulting in a genetic diversity of over 98% (Table 3). With a good management, a genetic diversity of 90% can be maintained for almost 500 years.

	Current	Potential
Pedigree known	100%	
Genetic diversity (GD)	98.4%	99.4%
Founder Genome Equivalents (FGE)	32.0	81.9
Population mean kinship (MK)	0.016	
Mean inbreeding (F)	0.004	
Founders	93	12
Effective population size/census size ratio (Ne / N)	0.36 based on 55 breeding males and 128 breeding females.	

Table 3: Genetic summary of the population.

The population is genetically very diverse and theoretically at least, could even further increase by breeding with genetically underrepresented individuals. The main reason for the loss of genetic diversity will be inevitable genetic drift now that the population size is maintained, which will cause genetic diversity to be lost slowly but surely. To maintain all evolutionary relevant genetic diversity, around 97.5% genetic diversity of the wild source population should be maintained (Frankham et al., 2010). In isolation and without additional tools, the EEP is projected to reach this point by 2083. Low levels of inbreeding, so cousin level or lower, cannot be avoided in long-term *ex situ* populations and are also thought to be generally harmless.

Incidences of higher levels of inbreeding, so above cousin level, become increasingly more difficult to minimise once genetic diversity falls below 95%. The EEP is projected, in isolation, to be able to maintain this level for 200 years. Together with other regions, a much higher level of genetic diversity is maintained for many centuries more. As such, a smaller EEP population size or less accurate genetic management, is unlikely to have a significant effect on the ability of the EEP to function as (part of) an insurance population of the original wild population. Moreover, if tools such as cryopreservation of reproductive cell lines will indeed be successfully used as later discussed in this document, this could with a modest number of samples already allow the EEP to functionally halt the loss of genetic diversity altogether. Even if it may not be essential to maintain this level of genetic diversity from a species conservation perspective, it does allow conservation on the level of genetic variation.

2.4.7.5 Management strategies

The EEP will aim to maintain the population size for the foreseeable future, which will require a reduction in breeding compared to recent years.
The proportion of males in the population has increased over time and is expected to increase further. This is challenging because harem groups are formed by one adult male and several adult females, and the already existing lack of space becomes even more acute. The solution to this challenge will likely require considerable investment in new enclosures, patience from participant institutions regarding breeding recommendations and other management strategies discussed below.

Non-breeding harem groups

Non-breeding harem groups, so that are not meant to breed at the moment, such as older individuals, will become more common now that the EEP is moving towards increasing the number of harem groups and reducing the birth rate. This option allows several opportunities.

A non-breeding harem group may be relatively easy to start with for unexperienced institutions (and regions) that may join the EEP in the future, and in case much easier to start with than a bachelor group. Furthermore, it allows the option to vasectomise the male, which is thought to allow for more natural breeding behaviour than contracepting the females.

Bachelor groups

Males with a low chance for breeding due to a bad MK can be placed in bachelor groups from the age of 5 years on. Sometimes this is also a transitory destination for future breeding males if incompatibilities in their familiar groups arise. These bachelor groups are closely monitored, as when animals grow older some incompatibilities usually appear.

Castration

The GEEP SC has decided that castration of young gorilla males ideally between the ages of 24 and 48 months is one of the necessary methods to prevent or decrease the male problem. The castrated males can either stay in their natal group, or will be integrated into a bachelor group or a family group at another institution. Zoos that have castrated a male will participate in a long-term research project that monitors the physical and behavioral development of the animal, as this information will be very valuable for future management decisions.

2.4.7.6 Collaboration with other regions

The EEP has been and is still supporting zoos in other regions to keep gorillas and to build up a population of Western lowland gorilla. By following the Best Practice Guidelines we try to push higher standards in husbandry for the purpose of conservation, raising awareness for the species and for the broader biological education of the public. However, the EEP does not aim to run a global programme. Because the coordination of the existing EEP population is already very complex. Therefore, the goal is that other regions manage their own regional population long-term. This would then be, similar to the way that the EEP

collaborates with the ASMP, so with decentralised management, but of course in cooperation with the larger *ex situ* population.

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2.5 Behavioural Enrichment

Behavioural 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.

2.5.1 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.

2.5.2. 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.

2.5.3. 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.

2.5.4 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.

2.5.5 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.

2.5.6 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.

2.5.7 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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2.6 Handling & transport

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.

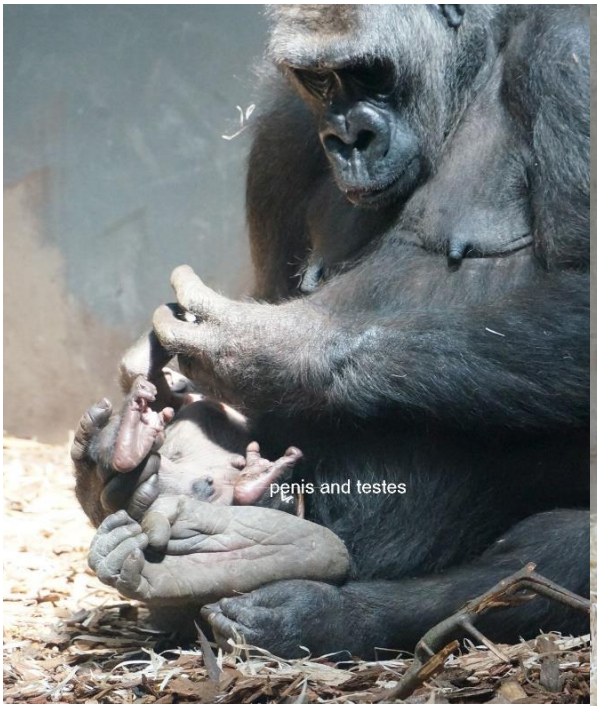
2.6.1 Individual Identification and Sexing

Individual identification
Experienced keepers easily recognize gorilla individuality. Each individual shows some facial features and coprotal characteristics that allow for identification.
It is adviced and required to identify any individual with a microchip. This can be done when a transport is planned and the individual needs to be anesthetized, or if it is anesthetized earlier for other reasons.

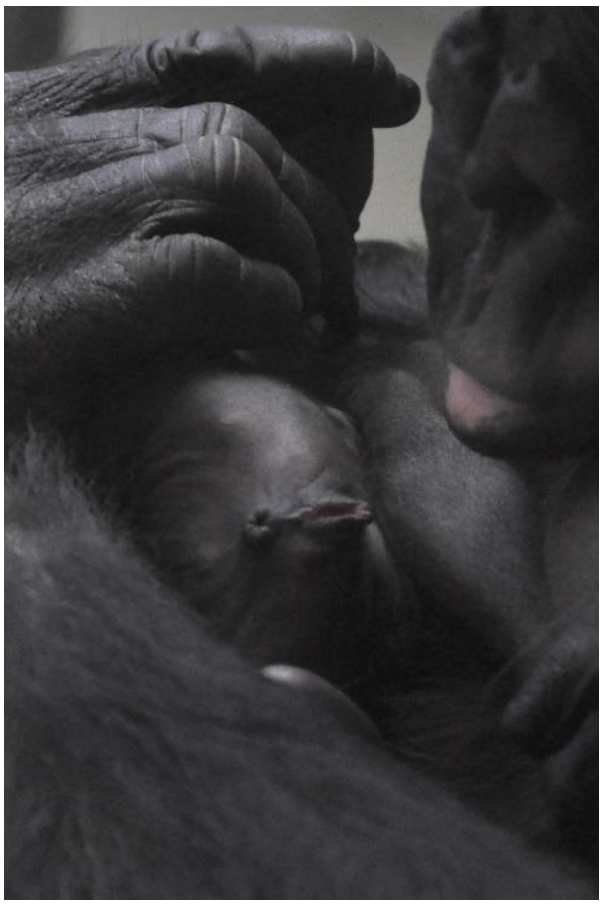
Sexing
Sexing an infant gorilla is not that easy!

Look at this photo - What you see is NOT a penis!

MALE:



FEMALE:



If you are very lucky, you can have a look from this perspective. Note the narrower septum gap between the vulva and the anus as compared to the penis/testes and anus in males

Now you know it is a FEMALE!

2.6.2 General Handling

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.

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.

Assisted-reared gorillas

Rearing history has a significant influence on how gorillas relate to their keepers. Assisted-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 assisted-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)

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.

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.

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.

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.)

- 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).

2.6.3 Catching/Restraining

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.

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.

2.6.4 Transportation

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.

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:
    a. the recommendations in the health section of this manual
    b. requirements of appropriate regulatory agency
    c. requirements of the receiving institution.

2.6.5 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

2.7 Training

2.7.1 Introduction

Most zoo and aquarium animals will at some point in their life face procedures that will include restraint and treatment – be it for transportation, research, veterinary procedures, and preventative health monitoring such as drawing blood and weighing. Usually, animals resist these procedures as they can include aversive stimuli and be stressful for them. Training of animals to enter transportation crates and accept voluntarily various husbandry and veterinary procedures – especially under protected contact – should become the standard at modern zoos and aquariums (Mellor et al. 2015). The goals and trained behaviours will vary across institutions depending on their specific basic requirements. Nevertheless, basic training for standard procedures should have priority in husbandry routine and focus on increasing the animal's welfare state in all operations (Laule 2003). Importantly, effective training can be achieved through short training sessions of only 5-10min (Videan et al. 2005, Laverick et al. 2014, Good et al. 2018). Short training sessions are even recommended as they correspond well with the attention span of the animals and keep motivation high. Training was done by keepers already in the past. It happens whether we mean to do so or not. Every interaction with an animal includes some form of training and communication. Sometimes, we are even being trained by the animal. So, why not doing it consciously and effectively in a structured way? Nowadays, training has a scientific background and is using operant conditioning techniques to obtain and maintain desired behaviours. Operant conditioning is a type of learning in which the probability of a behaviour recurring is increased (desired behaviour) or decreased (unwanted behaviour) by the consequences that follow. This includes positive reinforcement, negative reinforcement, and punishment (Melfi et al. 2020). Withdrawing attention from an animal (a brief period in which the trainer simply ignores an animal by walking or looking away from it) is one training tool that can be effectively used to communicate to an animal that it responded incorrectly and is the only recommended type of punishment (McLaughlin et al. 2007).

By rewarding desired behaviours and ignoring unwanted behaviour, positive reinforcement training (PRT) has become widely known and a necessary practice to reduce stress and to minimise the need to use tranquilisation. For many great ape species anaesthesia traditionally involved darting guns resulting in very aversive behaviours and stress which do not help to improve animal welfare, remove choice and control, and should only be applied when all training options have been exhausted or in emergencies. Furthermore, manual or drug restraint – apart from being very stressful for all involved parties – can potentially be detrimental to the animal's health. In gibbons, darting can result in significant lower induction quality compared to hand injections and darted animals may need a supplementary injection of an anaesthetic (Turner et al. 2018).
A study in chimpanzees could provide further evidence that hand injections can reduce factors associated with stress and improve the quality of anaesthesia in this species (Burrows et al. 2021). Hence, PRT has a direct and positive impact on the animal's welfare state. It not only offers interesting and stimulating events including choice and control but also entails a positive relationship between the trainer and the animal (cf. Mellor et al. 2020). Basic tools of PRT involve targets, primary (e. g. food or juice) and secondary (e.g. enrichment, scratching) reinforcers and a bridge like a clicker or a whistle. Please note, rewards - especially food - should be part of the nutritionally balanced diet to avoid weight issues.
For more details about tools and techniques of PRT please also consult the EAZA Animal Training Working Group.

2.7.2 Basic training goals

- Get access to animals and facilitation of daily management procedures

Animals can be trained with PRT to move to specific areas of their enclosures and shift voluntarily and efficiently on command for cleaning routine, and approach keepers and vet staff for visual inspections of different body parts or for facilitating various simple medical procedures (e. g. minor injuries) without the need to constrain the animal.

- Get animal's voluntary cooperation in veterinary, research, and husbandry procedures

Animals can be trained to voluntarily cooperate in various medical procedures and preventative health care without anaesthesia such as voluntary blood draws, weighing, monitoring the reproductive cycle of females, collecting urine samples, and even accepting hand injections to administer tranquilisation and improve anaesthesia. Training allows more direct physical contact to effectively treat illness and injuries and to collect important data for research under minimal stress for the animals involved.

- Reduce problematic behaviours, e. g. stereotypies

Training can be used to reduce or correct abnormal, neurotic, or stereotypic behaviour. After we determined what causes these behaviours, we can then start working on the problem solving and hopefully provide the animal with a behavioural alternative that - in the best case - can reduce or eliminate the need of the abnormal behaviour.

- Enhance socialization, reduce intragroup aggression, facilitate introductions, facilitate separations, and assist mothers or foster mothers in the care of neonates

Through various training approaches such as cooperative feeding, targeting, proximity and gentle touch training, and group shifting tension or aggression within a social group can be reduced by controlling aggression in dominant animals and fear in subdominant animals at the same time. Furthermore, individuals can be trained to separate from the group for a certain time and stay relaxed. This can be advantageous for various health procedures and certain medical trainings in which single individuals can be trained without being disturbed by others. Mothers and foster mothers can be assisted in the care of neonates in that they learn to tolerate bottle feeding of the neonate. This method can help to reduce the need for hand-raising babies or at least when hand-raising becomes necessary to reduce it to a very short time. This ultimately benefits the species-specific socialisation of the neonate and supports the early re- introduction of the neonate.

- Enhance environmental enrichment programs

One of the many advantages of PRT is that it is enriching itself. Animals are mentally stimulated, engage in goal-directed behaviour, exert agency, and can work for food they like. It challenges animals mentally and physically. Furthermore, training can enhance enrichment programs in that it can be used to teach animals to use new complex enrichment objects to expand the enrichment options they are already used to.

- Education of the public, and improvement of public and professional reputation

If the facility allows, PRT can be made visible for the public. Demonstrating how effective PRT is and how it improves the animal's welfare is an excellent message to the public as well as to other professionals who might profit from certain experiences. It will help educate the public about the level of care provided to animals in our institutions and help them understand how animals are managed in a respectful manner providing them with choice and control.

2.7.3 Advantages of PRT for keeper staff, animals, and the institution

- Training helps keeper to improve safety and improve job experience
  - Less physical restraint of animals
  - Less aggressive behaviour towards keepers
  - Improve keeper-animal relationship
  - Animal cooperation facilitates daily routine
  - Training saves time in daily management
  - Gain new skills and proactively use them on the job
  - Increase job skills and individual marketability

- Training helps to improve the animal's welfare
  - Less stress associated with daily management, husbandry, and veterinary care
  - Reduce the use of anaesthesia and physical restraint
  - Enhance mental stimulation, physical activity, and providing increased behavioural opportunities as autonomous agents
  - More choice and control
  - More enrichment
  - Increased trust towards the keeper staff
  - Enhanced positive social interactions, reduced aggression, facilitation of introduction as well as separations

- Training is beneficial for the institution
  - Exceed Animal Welfare regulations and legislations
  - Enhance public understanding and appreciation
  - Improved health care for animals
  - More effective daily management
  - Less animal health care costs
  - Less risk of keeper staff and animal injury
  - Demonstrate high standards of animal care

Recommended priority training list

Standard	Recommended	Advanced
• Shifting between locations • Administer oral medications (e.g. contraception pill) • Presenting & visual inspection of different body parts • Treatment of minor injures • Stationing • Drinking from bottle • Etc	• Hand injections for anaesthesia • Weighing • Nail trimming • Recall • Abdominal ultrasound for pregnancy detection • Crate training • ECG through KardiaMobile • Etc	• Blood draw • Heart ultrasound • Heart ECG • Artificial insemination • Etc

2.7.4 Practical implications

Several institutions have already implemented training in their daily husbandry routine and even adjusted their holding facility to attach training devices such as mesh or PVC sleeves to collect blood samples (Fig. 1). For more details on building instructions please consult the documents provided by the GATAG Welfare Group. However, some important training goals can be achieved without fancy installations. Hence, hand injections can easily be trained through standard mesh openings of 50mm x 50-100mm. As animals are often already trained to present different body parts, an important first step in training hand injections is already done. Most animals are used to present the shoulder to keepers. Now the other necessary training steps can be added (Figure 2). An example of a shaping plan to train hand injections and voluntary blood draws is included in this chapter. A very useful and elegant option used by some institutions is to install a “training cage”, which can be attached to holding rooms and used to transport the animal within the same facility or between buildings (e.g. veterinary station) without anaesthesia (ask Frankfurt for picture, used for bonobos).

When building a new facility, it is recommended to also install a permanent scale within the holding area to assist staff with weight monitoring. Several types of scales are used in various institutions. If a permanent scale is not an option also mobile scales may be practical and will do the job. This also helps keepers to determine when diet increases are necessary to ensure growth and development of infant and juvenile animals. Furthermore, actual weights of animals help veterinary staff to better calculate precise dosages of medication and anaesthesia.

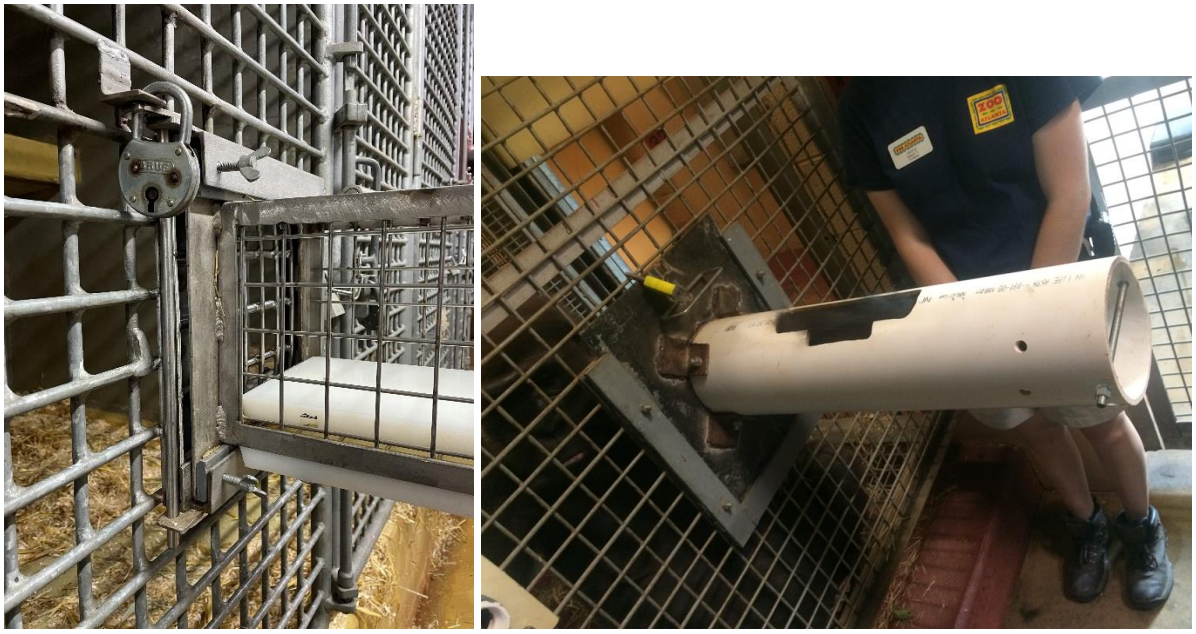


Figure 1: Examples of a mesh blood sleeve attached to holding rooms in Zoo Zurich and a PVC blood sleeve used in Atlanta Zoo (ask Matyas/Atlanta for courtesy).

Figure 2: Training for hand injections in a silverback (Zoo Zurich). Gorillas can be more challenging to train than other great apes.

2.7.5 Shaping plan for training hand Injections and voluntary blood draws

Animals are separated individually for both kind of trainings. Separation from the social group is a training process in itself and must be introduced carefully. During training, the animals remain at all times in visual contact with other group members. Mothers train together with their dependent offspring.

Training for hand injection training can be performed by one person, i. e. the trainer. Training for voluntary blood draw is more complex and may involve different persons for different roles, i. e. the trainer (responsible for security and positioning), the reward-providing person and a technician (collecting blood). Experience showed that it is easier when the trainer does not need to provide the reward. The sleeve is a large object and it is unpractical to move around it to provide the reward in a timely fashion (Fig.3). However, this may vary from institution to institution and is dependent on available staff and experience.

Training for injections and blood draws are demanding – for animals and trainers. Keep training sessions short and vary them with other behaviours.

Remember that we cannot take the pain of a piercing needle away, so do not repeat too frequently.

Figure 3. Training for voluntary blood draw is more complex and may involve different persons for different roles (Zoo Zurich).

2.7.5.1 Training Hand Injections

Goal: Train ape to present proper body part (typically shoulder) for IM injection.

Application: Ape should be trained to present for injections, including those needed for anaesthesia to reduce stress accompanied with darting guns.

Equipment: Syringes, blunt needle, real needle, antiseptic wash, cotton and/or gauze.

Shaping steps (exemplary):

1. The separated individual is sitting in a relaxed manner in front of the trainer.
2. Upon a specific cue, i. e. « shoulder », the individual positions itself laterally towards the trainer with upper arm pressed against barrier (with the help of a target).
3. Use finger to touch the injection site. Start with no pressure and no duration. Then build each aspect independently until both can be done together.
4. Begin desensitization to all equipment. Introduce each item one at a time and observe comfort level. Do not touch the individual, just present item, bridge and reinforce.
5. Move items closer until item touches the individual. Begin desensitization to touching with syringe. Then begin to work on increased pressure and duration by building up to 10-20 seconds.
6. Desensitize the injection site being rubbed with an alcohol gauze. If necessary, first introduce the gauze without alcohol and then combine.
7. Desensitize to the experience of steady pressure with blunt needle. When good duration and tolerance of blunt needle is achieved, desensitize to the real needle.
8. Desensitize to the needle piercing the skin. Always provide a huge reward, i. e. a jackpot for this.
9. Desensitize to the feeling of injection by using physiologic salt solution. Start with a small amount and increase as appropriate.

2.7.5.2 Training Voluntary Blood Draws

Goal: Train ape to present arm in PVC/mesh sleeve for venous blood collection.

Application: Ape should be trained to present arm in PVC/mesh sleeve for venous blood collection enabling a regular monitoring of different health parameters without the need of anaesthesia.

Equipment: Sleeve, butterfly (tubing) with blunt and real needles, antiseptic wash, cotton and/or gauze.

Shaping steps (exemplary):

1. Introduce sleeve to all animals. Give them the opportunity to touch, smell and manipulate it. When the sleeve is no longer perceived as something « special», start training.
2. The separated individual is sitting in a relaxed manner in front of the trainer and the sleeve.
3. The individual presents arm in sleeve.
4. Use a dowel stick to position arm within sleeve. The individual is holding the dowel stick with its fingers.
5. The individual tolerates the keeper’s hand on fingers holding the dowel stick (safety reason).
6. Use finger to touch the injection site. Start with no pressure and no duration. Then build each aspect independently until both can be done together.
7. Begin desensitization to all equipment. Introduce each item one at a time and observe comfort level. Do not touch the individual, just present item, bridge and reinforce.

8. Move items closer until item touches the individual. Begin desensitization to touching with butterfly (tubing). Then begin to work on increased pressure and duration by building up to 10-20 seconds.
9. Desensitize the injection site being rubbed with an alcohol gauze. If necessary, first introduce the gauze without alcohol and then combine.
10. Desensitize to the experience of steady pressure with blunt needle. When good duration and tolerance of blunt needle is achieved, desensitize to the real needle.
11. Desensitize to the needle piercing the skin. Always provide a huge reward, i. e. a jackpot for this.
12. Desensitize to the feeling of a blood draw by increasing the time the butterfly needle is in the vein.

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2.8. Veterinary guidelines

2.8.1 Introduction

While this chapter provides a brief overview of gorilla health, the reader is referred to more detailed textbooks, as well as the EAZA Great Ape TAG Veterinary Guidelines for further information. Additionally, relevant state, national and international legislation should be also taken into consideration.
These guidelines are for the use of zoo staff involved in the management of apes. 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 knowledge in the field of animal health as it applies for the species concerned. This means they must update their knowledge regularly, including information about relevant health regulations.

Whereas staff that care directly for apes must assume a large amount of responsibility for implementing the guidelines described, cooperation is also required from management 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 zoo's veterinarian, based on the assessment of risks as relevant to the institution and its animals.

2.8.2 Preventative Health

A comprehensive preventative health programme should consider both communicable (infectious) and non-communicable diseases. Based on retrospective analysis of cause of deaths in the European gorilla population, non-infectious causes are now the leading cause of mortality, a significant shift from what we have seen a few decades ago. These include external causes (most notably trauma of younger individuals), cardiovascular, gastrointestinal and other diseases. Infectious diseases might have a more significant impact on juvenile and subadult gorillas, while degenerative diseases dominate in aged animals. Adapting to the age and social structure of the group is an important aspect when designing a preventative health programme.

Disease aetiology and progression, as well as the complex interaction of potential contributing factors in non-communicable diseases are poorly understood in gorillas. However, from human studies it is well known, that over 70% of deaths are currently caused by these diseases in human, many causing premature death. Excluding tobacco use and alcohol consumption, other significant factors contributing to these diseases are nutritional and lifestyle related, including the lack of adequate exercise. Extrapolating from this information, it is very likely, that good husbandry, species specific nutrition, the opportunity for plenty of physical exercise, and appropriate social grouping are key in the prevention and mitigation of non-communicable diseases in gorillas. These guidelines provide detailed description of best practice facility design, care practices, training, nutrition, enrichment, and other elements, which all contribute to optimal health outcomes, elsewhere. Therefore, this chapter will not review these in detail, the reader is referred to the relevant other chapters of these guidelines. Some specific, preventative health related considerations, however, are briefly outlined below.

Numerous pathogenic micro-organisms can also 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 (or other species) by staff working with more than one group. The attending veterinarian carries considerable responsibility for the well-being of the primates and staff, including for public health.
Infections shared by humans and other animals are called zoonoses, and non-human primates have always been noted for their zoonotic potential. However, most gorilla groups in Europe are nowadays composed of

zoo-bred individuals and imports of wild-caught animals are extremely uncommon. Given these factors in most European zoos, the animals might 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 of animals allows direct or indirect contact.

Diseases can be spread between non-human primates and humans by numerous ways, including physical contact (bites, scratches, exposure to excreted material), ingestion, inhalation, or through mucosa membranes. The way of exposure is also dependent on the infectious agent.
A comprehensive list of specific zoonotic diseases would exceed the size of this document. The Transmissible Disease Handbook of the EAZWV Infectious Disease Working Group, as well as the AAZV Infectious Disease Manual are both excellent tools to provide information for infectious disease prevention, diagnosis, and therapy, and offer deeper review of infectious agents relevant for zoos. Fact sheets in these publications include information about epidemiology, diagnosis and therapy; and institutions which can be contacted if more specific details are required.

2.8.2.1 Facility Design From An Animal Health Perspective

Enclosure design should minimize direct or indirect contact between gorillas and visitors. While direct contact between these two groups is very rare nowadays, good facility design should consider disease transmission through various ways, including aerosols and food or other item being thrown into the animals' enclosure. There has been documented cases of severe disease outbreaks (and animal deaths) due to disease transmission from both staff and visitors to gorillas in zoo settings, as well as from humans to gorillas in the wild. Generally, the risk visitors pose to the animals is higher, compared to staff, and therefore, more effort should be put on mitigating disease transmission in the public facing part of gorilla facilities. To prevent disease transmission from the visitors to gorillas, barriers should be solid (eg. glass panels, solid walls, etc), or an appropriate distance should be provided. While recommendations previously suggested 7m as an acceptable minimum distance between humans and animals to prevent aerosol transmission, other factors also need to be considered, including ventilation, and the possibility of inadvertently or deliberately throwing objects (including food) into the enclosure.

With the increasing popularity of mixed species exhibits, new challenges in disease transmission should also be considered. It is not recommended to create mixed species exhibits with Asian primates and gorillas, and understanding of the disease status and risk profiles of all cohabiting animals should be considered. While mixed species exhibits can bring significant benefits to animals and visitors alike, appropriate facility design is of utmost importance to prevent undue stress, injuries or even death of animals.

Trauma remains a significant cause of morbidity and mortality in gorillas, especially in younger individuals. A balance between an enriching environment and safety of the enclosure should be always evaluated. Sharp edges, drowning, trapping possibilities should be eliminated as much as possible. Arboreal or other escape routes, including creating loops between different rooms, for juveniles and/or subordinate animals can mitigate intraspecific aggression and are important in preventing injuries, especially in groups which undergo change in composition or otherwise unstable. This is especially important in bachelor groups, where aggression is expected as part of normal behaviour of the animals more frequently, than in family groups. Indoor enclosures should be designed so that apes can be separated easily in an off display 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 disinfected. It is important that at least one of these areas is large enough to facilitate the safe anaesthesia of a silverback, requiring enough space for multiple staff and equipment to be positioned safely

around the animal in dorsal recumbency. This area should be provided with adequate lighting for veterinary procedures, or facilitate the temporary installation of such lighting as required (see further in the Anaesthesia chapter).

Every gorilla facility should be equipped with, and animals accustomed to, scales large enough for the precise weighing of all individuals, including juveniles (in breeding groups) and silverbacks. Ideally these scales should be positioned that all animals can access it easily and as part of their day-to-day routine.
It is ideal if the facility enables safe medical training of the animals, including blood sampling and other more advanced activities. The reader is referred to the training section of these guidelines for further information.

2.8.2.2 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, and/or ponds and moats, which may require constant attention in this respect. Organisms such as *Shigella, Salmonella, Campylobacter, Chlamydia, Leptospira, Yersinia* and 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.

Therefore, attention is required to prevent the introduction of pest animals as far as possible. It is usually much easier to prevent the ingress of pests into an area through good facility design and construction principles, than retrospectively trying to deal with the situation. However, many zoo buildings are aged, and this creates significant challenges to pest proofing. Regardless, a comprehensive integrated pest management program must be in place, and this should include ongoing monitoring and adaptive management, reacting to the levels of pest activity as required. While an important element of this is the reduction of pest numbers through baiting or other methods of killing, consideration should be given how to reduce numbers through other methods, including reducing the availability of areas harbouring pests, food, and water, as well as entry routes into indoor exhibit areas.

2.8.2.3 Identification And Records

All staff working with gorillas should recognise each individual visually and by their name, however, all apes should also be reliably identified by the use of transponders. Transponders can be placed under the skin on the arms or between the shoulder blades to facilitate conscious reading of these through training. Specimen and medical records should be kept up to date and on an individual level. Records should capture any significant health issues, including diagnostic and therapeutic interventions, all anaesthesia events, collected samples, and laboratory results, as well as contraceptive status and any ongoing medication the animal might be on. Prior to any animal transfer, a copy of the individual's detailed medical records, and if necessary, those of other group members, should be forwarded to the receiving institution, or shared on ZIMS electronically. This should also include any previous imaging results if relevant, if not included in the medical records otherwise. Open communication between the veterinarians and animal care staff of the sending and receiving institutions is essential to exchange information of important health issues and the medical management of the population.

2.8.2.4 Nutrition

Gorilla nutrition is more complex, than that of some other primates and a detailed understanding of nutritional requirements, as well as nutritional ecology in the wild is recommended for all gorilla care and veterinary teams. Please refer for further details to the Feeding chapter of these guidelines.

2.8.2.5 Population Health Monitoring

The veterinarian responsible for the care of gorillas must design and implement a preventative health plan, which should incorporate a population health monitoring component. This should include the following considerations:

- Daily written reports about the health of all apes including any symptoms of disease, unusual or abnormal behaviour, births, deaths, veterinary treatments, etc.
- Faecal testing for pathogenic bacteria and parasites with a frequency appropriate based on the clinical history of the individual and their group. Where an infection with pathogenic bacteria or parasites has been treated, follow up faecal samples should be examined to establish the effectiveness of treatment.
- Regular body conditions scoring and weighing of all individuals, ideally monthly, but at least quarterly. Diets should be reviewed on a regular basis, at least annually, and adapted to the animals' needs and life stages.
- If there is a vaccination program, the vaccine status of each animal should be reviewed annually, and boosters given when appropriate.
- If apes are immobilized for any reason, blood samples should be collected for haematology, serum biochemistry and serology (incl. most common diseases like TB). Annual health exams/reviews can be carried out if the animals are trained for the necessary behaviours, however, anaesthesia for annual health checks are not necessary, unless local circumstances dictate otherwise (consult veterinary advisor).
- Serum and tissue samples should be collected and stored at preferable minus 80°C as and when the opportunity arises. Serum banks thus created can be valuable in the diagnosis or retrospective monitoring of diseases, the determination of vaccine efficacy, and in the screening for new diseases as they are described. Furthermore, serum banks represent a valuable research tool. If the zoo itself has no appropriate storage facility for these samples, those can be submitted to one of the EAZA Biobank hubs free of charge.
- In the case of any animal deaths, a complete most mortem examination must be performed (see below).
- It is recommended to obtain a good knowledge about the health status of the population. Thus, a minimal database about the animals should be established.
- A preventative health program for employees working with great apes should be in place (see below).

It is important that the population health monitoring program is adapted to the facility and its animals, therefore, it should be formulated by a veterinarian who is closely working with, and familiar with the zoo.

2.8.2.6 Vaccinations

Vaccination programmes depend on the region, available vaccines, the animals, and design of enclosures. Under certain circumstances it might be recommended to vaccinate apes against certain infectious diseases, though routine vaccination is currently not required. Most apes in European zoos are not vaccinated at all or only against certain common diseases. 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.

The following vaccines are available and can be considered in gorillas, but a risk-benefit analysis should be carried out prior to roll out of these.

Tetanus: Clinical tetanus has been reported in wild and captive primates, and is generally fatal, or requires critical care. Tetanus is not currently reported in European gorillas and many animals are not vaccinated. Three intra-muscular doses of tetanus vaccine (standard human tetanus toxoid containing 40 IU of tetanus toxoid per dose) 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 booster at 5–10-year intervals.

Measles, mumps, rubella (MMR): All apes are susceptible to measles. 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 can 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 immunosuppressed 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 not in Europe. Very low number of clinical cases are reported only from two countries around the world, and therefore the risk of infection of gorillas in European zoos is extremely low. Vaccination is therefore not recommended.

Rabies: All primates are susceptible and vaccination of outdoor housed apes in areas where rabies is endemic can be considered. Doses can be given from 4 months old, and the current human vaccination regime require 3 vaccines at days 0, 7 and 21-28, and a booster one year after the first dose. A single booster dose every 3 years following that is recommended if ongoing risk of exposure persists.

Influenza: All great apes are susceptible to influenza and vaccination can be considered on an annual basis always before the expected influenza season. Vaccination of staff working with great apes is an important measure and might be more practical and impactful.

SARS-CoV-2/COVID-19: There has been several COVID outbreaks in gorillas in zoos and therefore vaccination against this disease can be considered on a risk assessment basis. Human vaccines have been used in gorillas with good safety records, but efficacy is currently poorly understood. Vaccination of staff working with great apes is an important preventative measure.

Other diseases: Vaccination 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 other diseases, including bacterial meningitis, Haemophilus influenzae, Pneumococcus, viral hepatitis A and B. If apes are carriers of hepatitis B 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 and only induces limited immunity.

In general, it is recommended that 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

Post mortem examinations provide the ultimate diagnostic opportunity to understand more not only about the individual's health issues, but the health status of the group as well. Therefore, a thorough post-mortem examination with further diagnostics should be carried out by a competent and experienced veterinarian without unnecessary delay on all apes dying in a zoo.

Post mortem examination on great apes should be carried out in an appropriate facility, considering the potential of zoonotic diseases and contamination of the space. Only staff involved in the procedure should be present and personal protective equipment should be used as required. In animals which are considered potentially infectious with zoonotic diseases, a risk assessment should be carried out prior to the post mortem examination. Care should be taken with primates dying in quarantine as these animals must be assumed to be of higher zoonotic potential until proven otherwise.

It is recommended that a systematic process is followed, and the Great Ape TAG developed a specific post mortem guideline and form to facilitate this. It is important to inspect and describe all organs even when normal. If certain body parts will not be dissected due to specimen preservation, a postmortem CT scan can be carried out to establish references and to find any abnormalities.

The gross post mortem examination should include collection of samples from a range of organs as per the Great Ape TAG post mortem guidelines, even when they look normal. All abnormal organs should be also sampled and submitted for histopathology. Additional samples, including for bacteriology, virology, or parasitology should be collected and analysed as deemed necessary. All collected samples should be recorded on the post mortem report and sample submission for analysis or storage should be documented. Unsubmitted samples should be stored frozen or via other preservation methods as appropriate (eg. in alcohol or formalin) for future analysis. It is recommended to collect and submit the whole heart as per the post mortem protocol of the Ape Heart Project (https://twycrosszoo.org/conservation/research-at-twycross-zoo/ape-heart-project/). Other samples might be recommended to be collected for Gorilla EEP or Great Ape TAG approved research projects.

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

Every great ape death must be reported to the EEP coordinator, and the full post mortem report should be sent to the veterinary advisor as soon as possible. General great ape, and more specifically gorilla pathology textbooks are available to help interpreting post mortem findings. The veterinary advisor is available to consult on post mortem cases as necessary.

2.8.2.8 Animal Transfers

Planning

All animal transports should be planned adequately, taking into consideration of the specific circumstances of both the sending and receiving zoos. Prior to transport the following procedures are advised.

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 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. Even where both zoos are BALAI approved, it may be a further requirement either by the zoos or by the member state authorities that extra tests or quarantine/isolation be applied. This must be confirmed in writing before the movement of animals is allowed. 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.

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 animals involved, which may be required or requested by the partner zoo. In all cases personnel involved should have experience of working with apes and assisting in handling for pre-shipment and health management. 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.

A copy of the animal's records should be forwarded to the accepting zoo 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. 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.

Full clinical history should be supplied to the recipient zoo prior to shipment. This must include any current treatment or medication, and any significant diseases occurring within the sending zoo within a pre-agreed timeframe. 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.

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 time prior to transport. Institutes should check these specific requirements.

Preshipment Examination

The more medical information veterinarians know about the sending and receiving institution, the better preshipment examinations and necessary preventative medical treatments can be planned and initiated. Although European legislation reduced required 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 information.

A range of tests for disease agents and physiological parameters should be carried out by agreement with the receiving zoo prior to movement. Simultaneously, a general health check should be carried out. Full clinical examination under a general anaesthetic is usually recommended, including a careful assessment of weight, teeth, eyes, reproductive organs and identification (microchip).

Intradermal (palpebral) test for tuberculosis (*Mycobacterium tuberculosis* complex) using human and/or bovine tuberculin is recommended. In the case of a positive intradermal tuberculin test a range of other

screening tests should be considered including gamma-interferon test, the microscopic examination of sputum, radiography or CT scan of the lungs, culture of material recovered from bronchial washings and gastric lavage, and differentiation of acid-fast bacilli by PCR. Infection with non-pathogenic atypical *Mycobacteria* may cause a positive tuberculin test and should be always considered as a possibility.

Faecal screen for *Campylobacter, Salmonella, Shigella* and *Yersinia*, as well as faecal screening for endoparasites should be completed within 30 days prior to transport. Radiographs should be taken if requested by receiving zoo, as indicated by the clinical history and/or age of the individual. Only clinically relevant radiographs should be requested. Routine haematology and blood biochemistry profiles are usually requested.

Relevant vaccinations should be considered and the animal's status in this regard declared. Serological screening for diseases as agreed by the sending and receiving institutions should be carried out. Only clinically relevant testing should be requested, as immunological response to a microbiological agent does not always constitute disease or infection risk. A wider range of viral screening tests is generally appropriate for wild born animals. The zoos are recommended to discuss any pre-shipment testing with the veterinary advisor if required, especially in more complicated cases (eg. exports and imports between EU and third countries). There should be consideration given to how to interpret any positive results and if follow up testing will be carried out in these cases.

As pre-shipment testing is costly, labour intensive, and require the anaesthesia of the individual (which might be required again in quarantine at the receiving zoo, or for crating), early discussions between the sending and receiving zoos should be carried out to agree on timeframes and responsibilities. Ongoing communication is required to ensure the smooth running of the transport.

Quarantine

Quarantine is a traditional way of reducing the likelihood of introducing infectious agents to a zoo via transport of animals. While it is a useful tool, it's important to recognise that it is not going to provide 100% assurance, and the very nature of social isolation can cause significant animal welfare compromise. Therefore, a risk-based approach is generally recommended, and the receiving zoo's veterinarian should work collaboratively with the sending zoo to establish the most appropriate quarantine approach.

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 the animal's health status. Traditionally, quarantine lasts 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 disinfected but should fulfill all animal needs. The welfare of this highly social animal must be taken into consideration.

For the import of wild-born animals or animals from facilities of questionable/unkown veterinary standards, a specialised, very high standard quarantine facility, veterinary and keeper staff, are required. Quarantine time and screening depend on animal origin and results. It might be necessary to repeat tests to 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. Depending on the risks involved, several screening tests can be undertaken in quarantine:

Parasitology: Assessment of internal and external parasite burden. Repeated faecal tests (flotation, sedimentation, Baermann-Wetzel method) will be necessary to determine whether internal 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 specialised parasitologists to maximize the chances of detecting and identifying the more delicate protozoan parasites (*Enamoeba, 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.
Regarding the faecal screens and TB tests, even if these are negative pretransfer, the receiving institution should consider to repeat them during quarantine as some animals may become positive during or shortly after a move.

2.8.3 Guidelines For Public Health

Under workplace health and safety legislation, employers are required to assess the risks, including those from infectious agents, to employees and other people who may be working with the animals and their by-products. Visitor, volunteer, student and other non-staff personnel health and safety should also be considered in this context. Where a risk is identified, appropriate preventative or control measures must be applied. A code of practice should be drafted in cooperation with a knowledgeable medical doctor or corporate health provider, in collaboration with the zoo's veterinarian. The veterinarian should inform the health provider about all potential and actual zoonotic diseases in the zoo. Transfer of know-how is essential for preventative health care.

Staff should be made aware and reminded 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.

2.8.3.1 Pre-employment Staff Screening

To reduce the risk of disease transmission to primates, prospective new staff members should undergo pre-employment medical screening. Ideally, the candidate should undergo a thorough medical examination by the zoo's health provider, in which the vaccine status of the new employee should be reviewed. Faecal tests should be considered to establish whether the prospective staff member is carrying any pathogenic enteric bacteria or parasites, and TB screening is recommended.

The pre-employment screening should be suitable for the zoo's context and carried out maintaining the highest level of confidentiality, while also allowing for assurances to be given that staff won't pose potential health risks to the animals and vice verse.

2.8.3.2 Health Of Staff During Employment

It is essential that all staff members are in good general health. Many human infections, including common respiratory viruses like cold, flu and COVID-19, can be passed to primates and may cause serious disease in gorillas. Staff with acute infectious diseases, especially with respiratory and gastrointestinal signs, should avoid having contact with gorillas or must take appropriate precautions if this is unavoidable (including PPE). Staff members who are immunocompromised for any reason (including pregnancy) should seek specialist advice. Annual faecal tests for pathogenic bacteria and parasites are advised, each staff member should maintain the required vaccination status, and regular TB screening should be considered and offered as appropriate.

It is important to recognise that different zoo's might have different risk profiles, dependent on the clinical history of their animals, the layout of facilities and working practices. Therefore, blanket rules are neither appropriate, nor helpful in establishing the best approach to ongoing preventative health care of staff.

All injuries, accidents and illnesses of staff should be recorded and reported as per the zoo's standard procedures. Bites and scratches should be immediately thoroughly washed (not scrubbed) and medical attention sought. People with open cuts or sores on their hands must wear plasters as appropriate and disposable gloves when working 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.

2.8.3.3 Staff Personal Hygiene

High standards of personal hygiene are required from primate keepers to prevent increased risks of zoonotic disease transmission. Frequent hand washing is probably the single most important measure to reduce or

prevent the spread of infection. Hand washing is particularly important immediately before and after working with any primates directly, or preparing/offering food for them. Hands should always be washed after handling bedding and other enclosure materials, uneaten animal food, faeces, and any other bodily 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 hands effectively and sufficiently often, it is vital that suitable facilities are provided. These are best placed just outside animal holding areas. It is recommended that visual reminders are placed at strategic positions to encourage frequent hand washing, and appropriate hand hygiene practices. When hand washing is not available, a suitable hand sanitiser product should be made available.

It is best practice for animal staff to wear a range of protective clothing when working in primate facilities. This involves the use of overalls or work uniform, rubber boots or work boots not used outside the zoo, and disposable gloves. Protective goggles, or face shields, 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 with any wild-born primate. Zoos are strongly advised to consult their veterinarian to assess the level of protection that is appropriate.

Work clothes should be washed in the zoo or sent in sealed bags to a laundry and should not be taken home by staff. Working clothes used in great ape areas or in the enclosure should not be worn in restaurants or off zoo premises.

Disinfectant mats can be placed at entrances to provide boot cleaning and disinfection. However, these require ongoing maintenance and replacement/top-up of disinfectant, to prevent them becoming a contamination risk themselves.

Staff should be encouraged to keep hands away from their face when working in animal areas. 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.

2.8.3.4 Enclosure Cleaning And Disinfection

Protective clothing (overalls, boots, disposable gloves, masks, goggles, etc) should be worn when cleaning animal areas. Bedding and excreta should be removed in sealed bags or adequate containers and disposed of in a compliant way as per local regulations. Animal areas should be cleaned 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. If these are used, a risk assessment should be carried out and appropriate PPE should be provided for staff, including respiratory protection.

Regular disinfection of primate facilities 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 disease from time to time. A thorough disinfection is recommended at suitable intervals with an effective product. Animal care staff should discuss this with the zoo's veterinarian to establish an effective cleaning and disinfection routine.
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 degradation. Too dry or too wet substrates can both create health risks to humans and animals.

2.8.3.5 Equipment

Restraint equipment should always be in good working order. Defective equipment can lead to injuries to animals and humans, and in the worst case, to escapes. Equipment must be cleaned after each job to avoid the mechanical transmission of infectious material. Needles, darts and surgical instruments should be handled with extreme care as after use they might be contaminated with various bacteria and viruses.

2.8.3.6 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 animal houses and between different zoos/sites. Veterinarians must ensure the correct disposal of clinical waste and follow the specific procedures for sharps disposal. The veterinarian is advised to visit the gorillas on a regular basis so the animals adjust to the veterinarian's presence.

2.8.3.7 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 themselves as well. 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, need careful consideration. Direct contact between apes and non-staff personnel should be strictly forbidden. Under no circumstances should children be allowed to have direct contact with juvenile apes. If close contact is unavoidable, within a distance of 1,5m, an N95 or equivalent facemask should be worn by visitors to prevent disease transmission.

2.8.4 Specific Health Concerns In Gorillas

2.8.4.1 Obesity

Many zoo-housed gorillas are considered overweight, often because of unsuitable diet and lack of physical exercise. As gorillas are considered frugivorous in the wild, many zoo diets have historically contained a large proportion of fruit. However, when looking at the nutritional composition of these cultivated fruits in comparison to their wild counterparts, it is evident that they are much higher in sugar and much lower in fibre. Therefore, it is not recommended to include fruit in a gorilla diet, and it is best practice to replace these items with a variety of vegetables.

It is also difficult for many zoos to achieve an adequate amount of browse for their gorillas, which makes up a large proportion of their natural diet. By increasing the amount of browse given, it will not only increase fibre content in the diet, but also offer other behavioural benefits such as natural nest building, bark stripping and tool use.

It is also difficult to encourage gorillas to exercise in a confined area such as a zoo enclosure, therefore extra care and time must be taken to facilitate increased travel and movement throughout the day. This can include spreading food out, increasing the amount of scatter feeds that contain small items, suspending browse and other items up high and using enrichment devices that may result in increased movement or suspension.

2.8.4.2 Gastrointestinal Diseases

Gorillas have a complex digestive system, which is significantly different from the human GI tract. Optimal nutrition, which should provide a low sugar, high fibre diet, is critically important to gorilla health. Chronic inflammation of the large intestines, including diseases mimicking human ulcerative colitis and Crohn's disease are very common in gorillas and can lead to bleeding into the gut and consequently to severe anaemia, perforation and gut "leakage" into the abdominal cavity, and then to peritonitis and death. The clinical diagnosis and management of these cases are challenging, and recovery is not always possible. There are gaps in our current understanding how and why these diseases develop in certain individuals, how to diagnose this early, and any preventative or curative actions we could be taking. However, it is important that optimal husbandry and nutrition is provided. Veterinarians are encouraged to contact the EEP vet advisor in complex cases of GI disease, as these tend of be chronic and frequently non- or poorly responsive to traditional treatment attempts.

2.8.4.3 Cardiovascular Diseases

Cardiovascular diseases are a leading cause of death in humans, chimpanzees, and bonobos, and a significant issue in gorillas as well. While in human's coronary artery disease is most common, in non-human great apes this is rare. A condition, called idiopathic myocardial fibrosis, is very commonly seen in chimpanzees and bonobos, and present in gorillas. However, in gorillas, other cardiovascular diseases, including hypertension, aortic stenosis, aneurism and dissection are also relatively common. While the underlying causes of these diseases are not well known yet, to some degree they are likely related to husbandry and nutrition practices. The role of vitamin D (or lack thereof) is currently being investigated in non-human great apes (see below). Obesity is also considered a potential factor which has significant impact on the development of cardiovascular diseases. The Ape Heart Project is an EAZA Great Ape TAG endorsed research initiative studying cardiovascular diseases in all four great apes. Gorilla EEP members are encouraged to participate in the project (http://twycrosszoo.org/conservation/research-at-twycross-zoo/current-research/ape-heart-project/). Advice is also available from an experienced team of veterinarians and cardiologists through the project.

2.8.4.4 Trauma And Other External/Environmental Factors

Especially in younger gorillas, trauma continues to be a major cause of death and threat to the welfare of animals. This can be caused by group members in playful or aggressive interactions, including infanticide from the silverback if he is introduced to a group where juveniles are present. However, other causes are also common, including falls from enclosure furniture, entanglement into ropes, and drowning, especially in enclosures bordered by water moats. Hypothermia is also a possible risk, especially in those countries where winter is cold and long. Many of these misadventures are preventable, and careful considerations should be given to facility design for any gorilla enclosures, but especially in those cases where breeding is planned. Young animals are much less experienced in weighing up environmental risks and are much more likely to be harmed in these situations.

2.8.4.5 Respiratory Diseases

All non-human great apes are susceptible to many human respiratory viruses and bacteria and these readily spread from staff or visitors to animals. There have been significant disease outbreaks, including deaths, linked to humans infecting gorillas both in the wild and in zoos. Therefore, good hygiene practices are paramount to prevent the spread of respiratory diseases. This should include appropriate separation of gorillas from visitors, as well as a staff training program and procedures in place to prevent unwell staff to work with the animals, use of personal protective equipment (primarily facemasks), frequent handwashing and other common methods of preventing disease transmission. In certain situations, vaccination of both staff and/or the animals might be a reasonable option, especially against seasonal influenza and COVID-19.

2.8.4.6 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 rapidly emerging in large parts of Europe. 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. foxes, 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. A semi-annual screening allows for an early infection detection and adequate treatment, which both are crucial to minimise 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. However, 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 is 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 in areas where the disease is endemic.

2.8.4.7 Vitamin Deficiency

Vitamin D is synthetised in great apes in the skin when UV radiation from sunshine is adequate. In many European zoos at least for a part of the year this is not the case, and therefore, similarly to humans in those locations, non-human great apes can easily become vitamin D deficient. Vitamin D deficiency is linked to

many diseases, in most severe cases rickets and pathological fractures of bones. More subtle cases might be contributing factors to cardiovascular, gastrointestinal, and other chronic/non-communicable diseases, as well as cancer, and reproductive failure. Research is currently underway to understand risk factors and preventative strategies, but unlimited outdoor access is an easy way to provide gorillas with as much sunshine and UV radiation as possible. Appropriate diet is also important, though at this stage there is no recommended nutritional guidelines for vitamin D in the diet for gorillas.

2.8.4.8 Gorillas With Non-specific Clinical Signs

It is not uncommon for gorillas to show nonspecific signs of ill health, with gradual loss of weight and body condition, with very limited findings on physical examination and generic screening tests. These cases can be extremely challenging from a veterinary perspective, and frustrating for all staff involved, especially if no significant improvement is achieved after prolonged periods of diagnostic and therapeutic attempts.

It is important to bear in mind that while gorillas are genetically closely related to humans, their gastrointestinal physiology is more similar to horses or rabbits. Therefore, while consulting human medical specialists can be extremely useful, we always need to keep in mind the differences between the two species.

In these cases, serious consideration should be given to assessing the psychosocial situation of the individual, and assessing any potential sources of stress, including recent changes in group composition, recent transport to another institution, or changes in the social dynamics (e.g. subadult males challenging the silverback). While behavioural changes might be subtle on the surface, these can have significant impact on individuals and can contribute to ill health. A multi-faceted approach is generally recommended and close collaboration between animal care and veterinary staff is required.

It is recommended that a general anaesthesia and a thorough health check is carried out relatively early on unless the animal requires stabilisation first. Leaving the anaesthesia for a later stage, at which point the animal might have lost significant condition and might be very unwell will increase the risk of anaesthesia. While a health check under general anaesthesia might not reveal the actual cause of ill health initially, it will provide valuable information about the physiological status of the animal and can rule in/out certain diseases. The health check regime should be tailored to the individual's need. If required, consultation with the EEP vet advisor and/or other experienced colleagues is encouraged early on in these cases.

2.8.5 Anaesthesia

As always, the anaesthetic protocol should be suited to the individual, any underlying (known or potential) diseases, and the circumstances of the planned procedure. There is currently a paucity of information on gorilla anaesthesia, and therefore evidence-based recommendations are difficult to be provided here. The follow summary represents guidelines based on personal experience and the existing literature, both for gorillas and other non-human great apes. It should be interpreted by a suitably qualified and experienced veterinary surgeon, and if necessary other, more experienced veterinarians and/or human anaesthesiologists should be consulted. The veterinary advisor is available for such remote consultation to plan anaesthetic procedures, especially in complex cases.

Every anaesthesia carries some risk, but it is important to consider what factors increase this. There is limited research on non-human great ape anaesthesia safety, but from the available literature it is clear that animals which are aged, or unwell carry a significantly increased anaesthesia related mortality risk. In other species the length of anaesthesia and procedural urgency were also shown to be important. As such, it is better to take a proactive approach and carry out anaesthesia when an animal is not (yet) critically sick. Leaving a diagnostic procedure too late in a progressive disease situation will likely exacerbate anaesthesia related risks, as well as lead to more severe disease which will be harder or slower to treat. Discussing these aspects between the veterinary and animal keeping teams early on is important, so everyone is aware of the realistic risks of various approaches. Keeping the length of anaesthesia as short as reasonably possible is probably also a useful strategy, if it does not lead to rushing the procedure or the omission of important tasks. However, it is always better to abandon a planned procedure unfinished and carry out a second anaesthetic at a later time, than persevering and losing the animal.

To ensure clear decision making and communication, there should be always a dedicated person to lead the anaesthesia. This person should be authorised to make decisions about all aspects of the anaesthetic event and others involved need to accept their leadership in this situation, independent of their reporting lines or seniority. If the anaesthetist veterinarian needs to step out of the procedure, even if only for a short time, there must be clear communication about who is going to take responsibility for the continuation of the anaesthesia. It is important to consider that most anaesthetic deaths do not happen in the maintenance period (which is usually the longest, but most stable), and therefore equal attention must be paid to the supervision of the induction and recovery phases as well.

The anaesthetic event should be thoroughly planned and discussed between veterinary and animal care staff, enabling ample time to prepare for it. If possible, the procedure should be planned to start at the beginning of the working day, to enable ample time for supervised recovery from anaesthesia. The location of the procedure should be carefully selected, and can be either within the gorilla's usual accommodation, if there is enough space available, or within veterinary facilities. Gorillas, especially silverbacks, are large animals, and it should not be underestimated how much space is required for the animal to be positioned in a safe and optimal way, with enough space remaining around the animal for all involved personnel. Small night quarters/dens might not provide enough space for this. Another consideration must of safety. Should a gorilla arouse unexpectedly from anaesthesia, the facility should enable prompt evacuation of the area, safe containment, and opportunity for re-darting the animal. For this reason, areas which are not able to contain the gorilla are not suitable for this purpose. These include spaces like unsecured corridors of animal houses, or other facilities, or outdoor spaces outside the gorilla's usual enclosure.

To enable the safe handling of the anaesthetised animal, a suitable number of helpers will be required, at least for certain parts of the anaesthetic procedure. As silverbacks can weight over 200kg, manual handling of them usually require 8-10 people and an appropriate stretcher or similar to spread the load. However, for the rest of the procedure personnel should be limited to those necessary. There should be always at least one, but ideally two escape routes available for staff operating in the immediate vicinity of the anaesthetised

animal for safety reasons. These exit points must be always staffed, so the area can be secured after prompt evacuation if required.

The work area needs to be adequately prepared for anaesthesia induction and the procedure. Any unnecessary objects, including enrichment and removable furnishing should be removed, and if possible, no high shelves should be available for the animal, as these pose a fall risk, which in certain cases proved fatal in the past. They also increase manual handling risks, should an animal fall asleep on the shelf. The area should be thoroughly cleaned, and bedding and other material removed as far as possible.
Gorillas must be isolated from their group prior to anaesthesia induction to prevent aggression from others towards the animal which will be losing consciousness. This also provides for a calmer induction in most cases, however, social isolation should be kept to a minimum, as in itself it is stressful in gorillas. For this reason, it is ideal if separation of the individual only happens immediately before anaesthetic induction, rather than the night before. To reduce stress further, veterinary staff should avoid presence during this time, and keeping staff should maintain normal routine as much as possible.

The preferred method of anaesthesia induction is through hand injection, which can be trained through positive reinforcement training. Details of this is well described in many species elsewhere and in most individuals is relatively straightforward. However, in most individuals a moderate level of sedation via premedication is likely beneficial, and therefore, generally recommended, unless otherwise indicated. This can be done with oral diazepam, midazolam or alprazolam given as a one-off dose. Usual doses for these are 0,25 mg/kg, 0,5 mg/kg and 0,02 mg/kg, respectively, however, a wide dose range might be indicated dependent on the individual and their circumstances. Benzodiazepines are very safe, though high doses can cause significant sedation, to the point that hand injection might become impossible as the animal might not react to the usual training cues. There are many different formulations of the above drugs available, in liquid, or solid form. If an oral formulation is not readily available, it is acceptable to use an injectable formulation orally. The drugs can be mixed in small amount of liquid, for example fruit juice or yoghurt, as long as the volume is kept small, to facilitate administration. It can take 30-60 minutes to see the desired level of sedation, and generally it is recommended to wait 30-45 minutes before induction to enable optimal effect.

Induction can be carried out via hand injection (preferred) or darting. If darting, it is preferable to use a dart rifle or pistole, as some animals have the tendency to try to grab the muzzle, making the use of a blowdart less safe. It is generally not recommended to use a squeeze cage or crush with gorillas, due to the risk of injuries, as well as the stress involved. No direct contact should be attempted with gorillas other than with newborns or juveniles separated from their mother. If a mother/baby pair needs to be anaesthetised, the usual method is to induce anaesthesia in the mother first, and when safe to do so, remove the baby for induction separately.

Several anaesthetic induction drugs and drug combinations are possible, and selection between these is partly based on personal preference and experience with these drugs, as well as the health status of the individual, the planned procedure, and other circumstances. A frequently used combination is 0.02 mg/kg medetomidine with 2 mg/kg tiletamine-zolazepam. This combination provides relatively quick anaesthesia induction, good muscle relaxation, and appropriate safety. Combined with the above outlined oral premedication the likelihood of sudden arousal is low, but not impossible, therefore, especially for longer procedures, inhalational or IV anaesthetic maintenance is recommended. Alpha-2-agonists also cause significant cardiovascular side effects and are generally not recommended in very young, elderly, or unwell animals, especially if the individual is a suspect or confirmed case of heart disease. Combined with inhalational anaesthetics alpha-2-agonists can cause severe hypotension and poor tissue perfusion, which can be life threatening if untreated. Appropriate monitoring is therefore required. An alternative induction drug can be tiletamin-zolazepam on its own. The dose might need to be higher in this case compared to the above, however, a wide dose range is possible depending on the individual and the desired length of

anaesthesia. This combination has limited side effects but doesn't provide as good muscle relaxation as when combined with alpha-2-agonists, and a typical side effect is involuntary muscle twitching or minor movements of the lips, fingers or toes. Staff should be familiar with this side effect and be able to distinguish this from a too superficial state of anaesthesia for safety reasons. Other induction drugs are possible and might be indicated in specific situations, and can include ketamine alone (not recommended for usual cases), ketamine combined with alpha-2-agonsists and/or benzodiazepines, potent opiates, or mask induction of inhalant anaesthetics in newborns. The risks and benefits of each combination is beyond the scope of this document, and the reader is referred to the anaesthesia literature. Personal experience, and specifically experience with certain drug combination(s) can play significant role in anaesthesia safety. New or previously unused drug combinations should be reserved for healthy, low risk animals in the ASA 1 category to gain experience.

If it is required due to the length of the procedure, anaesthesia maintenance can be either via inhalation, or intravenous anaesthesia, or a combination of the two. There are pros and cons for each of these, but in normal clinical practice some use of inhalation anaesthesia is common. In most cases the animal is intubated using a standard endotracheal tube (prepare a wide range of sizes if previous records are not available for the individual), but the use of laryngeal mask airways (LMA) can also provide good outcomes. The veterinarian supervising the anaesthetic event should be familiar with the techniques and side effects of inhalation anaesthesia, and ready to treat those, including severe hypotension. It is recommended that animals are provided with two intravenous catheters for redundancy, and one of these should be reserved for IV fluids, which should be routinely provided. Flow rate should match the animal's requirement and can range for maintenance rate to high rates if the animal is hypotensive. Therefore, IV fluids should be adequately sized (500-1000 ml bags), including the IV line and catheter sizes. Treatment of hypotension and other anaesthesia side effects follow similar methods as in other animals. Even if inhalational anaesthesia is not used, oxygen should be always provided. If the animal is not intubated, intranasal oxygen delivery is appropriate, pending the flow rate is high enough.

Depending on the length of the anaesthesia, as well as desired recovery process, reversal of many of the premedication and induction drugs are readily available. For most routine cases reversal is likely a good option, and can include flumazenil (0,003 mg/kg IV, if necessary repeated to effect) for the reversal of benzodiazepines, and atipamezole (5 times the dose of medetomidine, IM) for the reversal of alpha-2-agonists. If opiates were used, these can also be reversed by full or partial opiate antagonists, but consideration should be given to pain relief, if they were used for intraoperative analgesia.

Throughout the anaesthesia, whenever it is safe to do so, close monitoring of the animal should be carried out. Pulseoximeter sensors can be used on the tongue or lips, as the dark skin colour makes their use challenging on many other body parts. Capnography can be easily used in intubated animals, or those fitted with an LMA, but even non-intubated animals can be monitored through nasal sampling, though the reliability might be suboptimal. Blood pressure monitoring is an important and relatively simple method using non-invasive methods, most commonly either through an oscillometric NIBP machine, or using the traditional auscultation method, though doppler monitoring is also suitable. In more compromised animals an invasive blood pressure line should be considered. ECG monitoring should be considered, especially in cases where cardiovascular changes are likely. Anaesthesia depth monitors are currently not validated in non-human great apes, but every effort should be made to regularly assess the depth of anaesthesia via reflexes. An adequate level of anaesthesia must be maintained throughout for safety, but an overly cautious approach can lead to severe anaesthesia side effects. Anaesthesia monitoring, most likely in a "hands-off", observational way, must be maintained throughout the induction and recovery periods as well. There should be pre-agreed rules about what the team will (or will not) attempt to do, should severe side effects, including respiratory or cardiac arrest happen during the anaesthesia, but especially if it happens at induction or recovery phase, when the animal might not be fully under the effect of the drugs. Human safety must take precedence in these situations and CPR should only be attempted if it is safe to do so.

The animal always should be recovered in a safe area, which is adequately small and simple to prevent injuries, but provides enough space for the animal to be able to sit and stand up, and move around. It is common to provide bedding (straw, woodwool, etc) during the recovery period to prevent heat loss. However, it is better not to use blankets or other material the animal can entangle into. Protection of the airways is one of the most important aspects during recovery as animals might regurgitate or vomit. There is also the possibility that a still unconscious but somewhat moving animal position itself in a way that their airways are blocked. Therefore, the animal should be positioned close to the mesh with the head/nose pointing towards those supervising the recovery. A slightly elevated head can help preventing aspiration. If the ET tube is left in place, this must be removed at the first sights of recovery. Some advocate for an early extubation to reduce or prevent irritation during the recovery period. If possible, pulsoximeter and/or capnograph sensor(s) should be left in place throughout the recovery through the mesh to ensure some monitoring of vital signs is ongoing. Failing that, at the very least visual monitoring of respiratory efforts and rate, as well as mucosa membrane colour should happen. Under no circumstances should any staff remain directly in the same space with a recovering gorilla, except in the case of newborns and young juveniles, due to human safety. The ideal recovery is gradual and can take 15-20 minutes or longer, but rough recoveries are possible. It is usually helpful to have familiar keeping staff around to try to calm the animal down, or even to attempt some basic positive reinforcement training when it is safe to do so to keep the animal steady. The individual should be reintroduced to their group as soon as safe to do so.

2.8.6 Diagnostics

Diagnostic methods should be selected and applied according to clinical presentation and the history of the individual, as well as group. Opportunistic sampling while an animal is anaesthetised for any reason is strongly recommended to establish baseline values for many parameters for the individual, as well as to support preventative medicine. Training for sample collection through positive reinforcement training should be encouraged and a close collaboration between veterinary and animal keeping staff should be established to prioritise and optimise this.

- If an animal is anaesthetised for any reason, the following baseline diagnostics are encouraged, dependent on available equipment and expertise:
- Complete physical examination, including oral examination;
- Blood collection for hematology and biochemical profile, including cholesterol, tryglycerides, fructosamine, glycosylated hemoglobin (HbA1c), NT-pro-BNP, troponin-I;
- Bank any surplus serum, plasma and whole blood frozen (-80C if possible, alternatively -20C short term, and shipment to the EAZA Biobank). Always collect more blood than what will be used for immediate testing in case any tests need to be re-run or follow up tests become necessary;
- Viral and parasitological serology as indicated by the history of the institution and group, or clinical presentation. Unnecessary screening for a wide range of viruses is however not routinely necessary and can create challenges with interpretation;
- Faeces for parasitology and enteric pathogen (*Salmonella, Shigella, Campylobacter, Yersinia*) culture and sensitivity. Consider sample collection and submission requirements for pathogenic protozoans, which are very sensitive and hard to diagnose;
- Routine urinalysis, including specific gravity and dip stick, and further laboratory testing if indicated;
- TB screening, as a minimum intradermal tuberculin test, unless the animal has been screed within the past 12 months. TB screening should be routinely carried out even if the facility maintained TB free status in the past, but testing frequency and diagnostic methods should be matched to the disease risk;
- Thoracic radiographs (VD);
- Abdominal radiographs if indicated, however, diagnostic value of these might be limited;
- Radiographs of selected joints in adult/elderly animals, inlcuding shoulders, elbows, knees and hands and feet;
- Dental radiographs if indicated by oral examination;
- Cardiovascular examination including ECG and echocardiography (for further details and advice see the Ape Heart Project website);
- Abdominal ultrasound if indicated;
- Digital photographs of any lesions, and the oral cavity;
- Research samples if requested (see EAZA Great Ape TAG and Gorilla EEP endorsed research projects list);
- Morphometric measurements if requested.

It is advisable to establish in-house normal values for most common diagnostics tests for each individual. Alternatively, ZIMS can provide valuable comparative information for tests where a normal range is not available for gorillas. For any disease screening, the veterinarian needs to understand what a positive or negative test result can mean, and how to (if at all) follow up on an unexpected test result.

2.8.7 Behavioural Medicine

The management of abnormal behaviour requires a multidisciplinary approach. 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 behavioural assessment, for which understanding natural behaviour of gorillas, both in the wild and in captivity, is a prerequisite. It should also be noted that many of the drugs that may be used in this area have potential for significant side effects in the animal, as well as human abuse potential, and so their prescription and use should be carefully controlled and monitored. Drugs alone are unlikely to be successfully in producing long lasting behavioural changes unless they are used in conjunction with a behavioural modification program. Teamwork between the veterinarian, the animal keepers and animal behaviorists, trainers and human medical professionals is essential to ensure a successful outcome.

Some of the common presentation of behavioural “problems” in gorillas include (di)stress, heightened aggression, abnormal repetitive behaviours (also called stereotypic behaviours), depression like states. It is important to recognise that some behaviours are part of the normal behavioural repertoire, and signs of stress, or aggression cannot be simple considered as a medical problem. A thorough understanding of the history of the animal, any potential causative factors, including the social situation, husbandry/management practices, and relationship with animal care staff are important considerations. It is a significant challenge in diagnosing these problems that staff usually have limited time to observe the animals directly. However, without enough behavioural data, it is likely impossible to pinpoint triggers for behavioural changes, as well as improvement opportunities in the facility design or care practices which could positively influence the animal’s state. While drugs can mask some of the overt behavioural signs, this can exacerbate the problem longer term. Therefore, careful consideration should be given to how to implement a thorough, but practical management and monitoring of these cases, in collaboration with animal care staff. Optimising social and husbandry/management factors should be the first step in trying to resolve these cases. The diagnostic plan should include a full health check to identify potential underlying health issues. For example, pain, especially if chronic, is a common contributing factor to significant behavioural changes in animals, but its expression might be different between individuals ranging from decreased activity or even apathy to increased aggression or hyperactivity. Likewise, unnatural social groupings (eg. social isolation) or sudden changes in the social situation (e.g. transfer to another zoo or death of another group member) can trigger significant behavioural changes or induce abnormal behaviours.

It is common in gorillas, that they undergo a longer adjustment phase after being transferred to a new group or are exposed to a significant social change. Some animals cope with this very well, while others develop severe clinical signs of ill health, sometimes without clearly identifiable causes. These cases require early attention and careful management. Veterinarians should consider stress, and especially social stress in this species, as a potential contributing factor in cases where a clear aetiology cannot be identified and the history of the animal suggests this as a possibility.

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2.8.8 Reproductive Management

Details related to reproductive biology and management, including contraception is included in the Breeding chapter of these guidelines. In complex cases it is recommended to consult the EEP veterinary and/or reproduction advisor for further information.

2.8.9 Surgery

There has been significant progress made in the surgery of most zoo animals, including great apes in the last decades. A thorough overview of surgical techniques in gorillas is beyond the scope of these Guidelines, but the reader is referred to the many scientific papers describing select surgeries.

Suture removal is common in great apes, although careful suturing and attention to asepsis will greatly reduce the incidence. Intradermal skin closure is always recommended. Tissue glue may be used to provide complete closure. Excellent pain relief is of utmost important and is a significant factor in the prevention of surgical wound dehiscence. The old adage that “we should leave some pain, so the animal will leave the wound alone” is scientifically unfounded and would contravene animal welfare and practical considerations alike. Surgical pain relief should consider both intraoperative and postoperative analgesia.

2.8.10 References (Veterinary guidelines)

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2.9 Recommended research

2.9.1 Introduction

Scientific research engaged and/or facilitated by EAZA zoos is fundamental to excellent integrated species conservation in zoos (EAZA Research Standards, 2022). The gorilla EAZA Ex Situ Programme (EEP) underlines the importance of high quality research to continuously increase our knowledge on and optimise (population) management, husbandry & veterinarian practices, health- and behavioural monitoring and welfare of ex situ gorilla populations and individuals. In addition, the gorilla EEP encourages and promotes research supporting and contributing to the conservation of in situ gorilla populations. To this end, research projects with clear benefits to the EEP ex situ and/or in situ gorilla population(s) and/or individuals can request support from the gorilla EEP to stimulate contributions by EEP members. Research should adhere to the ethical standards for zoos and aquariums as formulated in the 'EAZA Code of Ethics' (EAZA, 2015) and the 'Ethical Guidelines for the conduct of research on animals by zoos and aquariums' (WAZA, 2005). Researchers can use the Great Ape TAG research application form to request support from the EEP by contacting the gorilla EEP coordinator, research advisor and/or Great Ape TAG chair. For studies involving only gorilla species, please contact the gorilla EEP coordinator. In case other great ape species are involved in the study, please contact the Great Ape TAG chair. Research applications will be reviewed by the gorilla EEP coordinators and advisors and/or by the Great Ape TAG chairs. EEP members are encouraged to engage in scientific research by either initiating and/or collaborating with gorilla EEP supported research, e.g. by providing (biological) samples, filling in questionnaires and/or sharing data on their individuals. For more information on how to get involved, please contact the EEP coordinator and/or Great Ape TAG chairs.

2.9.2 Research topics

Currently, the following research topics are identified as priority by the gorilla EEP specifically:

- **Genetics and conservation**: research on genetic diversity, gorilla subspecies and relatedness determination as part of a larger umbrella research project involving all great ape EEPs, in collaboration with the EAZA Biobank.

- **Veterinarian sciences**: understanding the conditions, treatment and prevention of common causes of mortality in great ape species, such as cardiac disease (Ape Heart Project), reproductive pathology and gastrointestinal disease.

- **Nutrition**: research studying the impact of diet and the gut microbiome on risk of cardiometabolic diseases in western lowland gorillas.

- Effect of **population management strategies** on behaviour & welfare (**bachelor groups**): monitoring behaviour, social dynamics and welfare of all-male groups of western lowland gorilla males in EEP zoos.

- Effect of **population management strategies** on behaviour & welfare (**castration**): monitoring the morphological- & behavioural development and welfare of castrated and intact male western lowland gorillas in EEP zoos.

- **Welfare**: developing a species-specific welfare assessment method for gorillas, identifying species-specific (behavioural) needs and studying the effects of (population) management and husbandry on gorilla welfare.

- **Welfare**: identifying factors influencing prevalence of abnormal (repetitive) behaviour in ex situ gorilla population.

- **Endocrinology**: investigating androgen development and possibilities for cryopreservation, e.g. by histological research of testes of castrated males.

- **Evolution & comparative sciences**: understanding the evolution of the primate brain (Ape Connectomics Project, by Primate Brain Bank).

Appropriate areas for further research recommended by the gorilla EEP are:

- Management of geriatric apes
- Management and factors influencing introductions of new gorilla individuals
- Factors determining birth sex ratios in gorillas/great apes
- Effect of population management strategies on behaviour & welfare (non-breeding groups): monitoring behaviour, social dynamics and welfare of non-breeding groups of western lowland gorillas in EEP zoos.

2.9.3 Useful documents

Also see http://www.eaza.net/members

1. Introduction questionnaire
2. Male Gorilla Annual Questionnaire (MGAQ)
3. Gorilla facilities review points

2.10 Specific Problems

2.10.1 Managing males

As a result of the equal sex-ratio in the animals born and the survival rate because of our increased expertise, the number of males that cannot be placed in a breeding situation is growing. Demographically and genetically sustainable management programmes often face this challenge mostly due to their own success.

As a gorilla breeding group is composed of one silverback and several females, more males than necessary for breeding purposes are born. In the latest long term management plan the population is analysed into detail, especially in regard to the "surplus male issue".(Bemment et al, 2021) Young males should stay in the family unit until they seriously start challenging their father and have to be separated to avoid injury. 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". Young males, which are "genetically surplus" have received a recommendation for castration to be able to permanently keep them in the harem group. 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:

- stretching the stay of young males in their natal groups
- castration of over-represented young males with a view to them staying in their natal groups
- removing over-represented males from their breeding group and keeping them separate with a son(s) or an old non-breeding female(s) from the former group
- keeping the males in bachelor groups
- reducing the number of breeding females per group
- development of techniques that control the sex ratio of the offspring
- euthanasia of surplus males

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 and selective abortion of foetuses.

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."

2.10.2 Bachelor groups

Preface

The establishment of bachelor groups in zoos was initiated 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.

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:

- 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 subadult male could stay in his natal group before joining a bachelor group is 6 to 9 years old

- Minimise the risk of inbreeding.

- Prevent the de-socialization of males who would otherwise be kept alone.

- 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.

Bachelor groups in the wild

The establishment of bachelor groups of gorillas in the wild (information on which has largely been derived from the Virunga population of Mountain gorilla) 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)**.**

Bachelor groups in zoos

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 subadults and blackbacks 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).

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. 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.	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.

(after Cory & Machamer, 2000)

2.10.3 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 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 antagonists.

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 30 June 2023, twenty six 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)
- 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; within the ASMP)
- 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)
- Orana Park, New Zealand (2015; within the ASMP)
- Pairi Daiza, Belgium – 2 Groups (2016)
- Al Ain, UAE (2018)

- Thoiry, France (July 2020)
- Mysore, India (August 2021)
- La Teste, France (May 2023)

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 the oldest individual 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 probably 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 blackback 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.

2.10.4 Castration

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. As of 31 December, 2022, 26 males have been castrated and all are still living in their natal groups.

2.10.5 Breeding strategy for female gorillas with *Alveolar echinococcosis*

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.

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