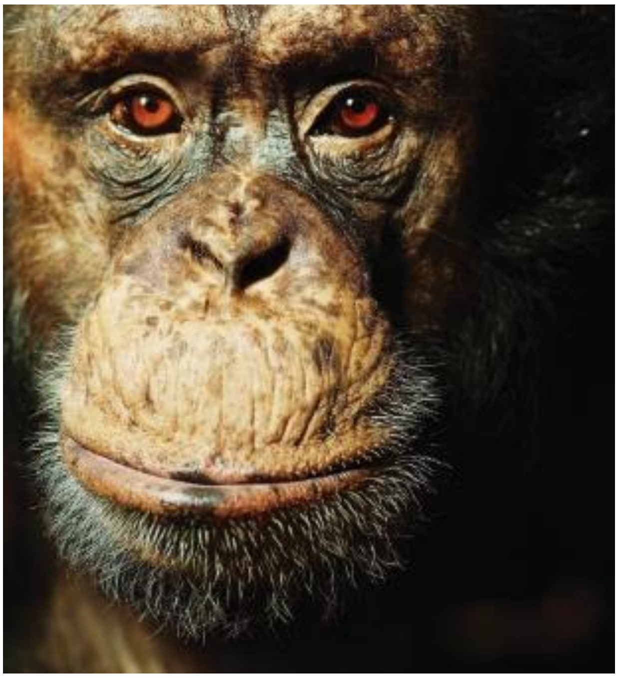


EAZA BEST PRACTICE GUIDELINES
Great Ape Taxon Advisory Group
Chimpanzees (*Pan troglodytes*)
2022 (1st edition)

Edited by

Frands Carlsen
Tom de Jongh (Burgers' Zoo)
Jana Pluháčková (Ostrava Zoo)

TAG Contacts:
Great Ape TAG chair: Mª Teresa Abello, Barcelona Zoo
Great Ape TAG vice-chair: Sandra Reichler, Heidelberg Zoo

Editors

EEP Coordinator 2002-2020 Frands Carlsen, Copenhagen Zoo
EEP Coordinator Jana Pluháčková, Ostrava Zoo
EEP Vice-coordinator Tom de Jongh, Burgers' Zoo, Arnhem

Contributors

Maria Teresa Abelló Poveda, Barcelona Zoo
Adrian Baumeyer, Basel Zoo
Frands Carlsen, Species 360
Veronica Cowl, EAZA RMG
Louise Cox, Dartmoor Zoological Society
Karin Federer, Walter Zoo
Yedra Feltrer, EAZA RMG
Tom de Jongh, Royal Burgers' Zoo, ret.
Charlotte Macdonald, Yorkshire Wildlife Park
Giuliano Matessi, Københavns Naturskole
Gerd Nötzold, Zoo Leipzig, ret.
Jana Pluháčková, Ostrava Zoo
Sharon Redrobe, Twycross Zoo
Barbara Regaiolli, Parco Natura Viva
Caterina Spiezio, Parco Natura Viva
Hanspeter Steinmetz, Munich Zoo
Raymond van der Meer, EAZA Executive Office
Lars Versteege, Safaripark Beekse Bergen
Jeroen Stevens, Universiteit Antwerpen

Reviewers

Francis Cabana, Wildlife Reserves Singapore
Anouk Fens, Apenheul
Amy Plowman, Bumblebee Conservation Trust

Recommended citation: Carlsen, F., T. de Jongh & J. Pluháčková (Eds.) 2022. EAZA Best Practice Guidelines for Chimpanzees (*Pan troglodytes*) - 1st edition. European Association of Zoos and Aquariums, Amsterdam, The Netherlands.

If not indicated otherwise, all pictures taken by the authors
First edition 2022

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.

HISTORY OF THE CHIMPANZEE EEP

At the meeting of the EAZA Primate TAG, Ape Subgroup in Alphen, 1994 it was decided that a structured management of the European chimpanzee population was urgently needed. There was no precise overview of the historical or extant population, the split on different subspecies or the level of hybridisation among these. As a consequence, an effort to identify chimpanzees of pure subspecies in the region has been ongoing since the following Primate TAG meeting in Poznan in 1995, and despite the initial limitations in available methods for subspecies testing of chimpanzees it was initially possible to identify a core group of western chimpanzees (*P .t verus*) in the aim of establishing an EEP for this subspecies.

The EEP for western chimpanzees was established in 2002 (Carlsen 2002). This was done somewhat prematurely, before a full survey of the population was conducted and the testing of selected specimens was concluded, primarily to protect the already identified specimens from unwanted transfers. This approach led to a situation with an existing EEP with very little breeding and transfer recommendations because the programme was not yet fully established.

A generic studbook was established in 2007 offering the needed overview of the population (Carlsen 2007) and in 2014 the joint EEP for all chimpanzees in EAZA was approved by the EEP Committee (Carlsen & de Jongh 2015). In 2007 the first strategy for future management of chimpanzees in EAZA was developed (Carlsen 2007; Carlsen & de Jongh 2009). This strategy was revised in 2014 (Carlsen & de Jongh 2015). The Long-Term Management Plan (LTMP) for the species was published in 2018 (Carlsen *et al.* 2018) and the programme is presently managed following the recommendations from the LTMP.

SUMMARY

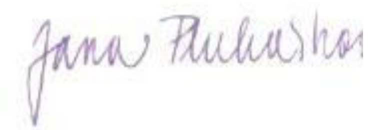
This document reflects our current knowledge about general biology and keeping requirements to provide adequate levels of wellbeing for chimpanzees. It provides information about different aspects that should be taken into account when managing chimpanzees in captivity to ensure a healthy and self-sustaining population, helping to the development of a global “ex situ conservation” program. It also provides information about the situation of the species in the wild and “in situ conservation” projects supporting field conservation in host countries, which all the zoo institutions keeping chimpanzees are encouraged to support following the IUCN strategy of One Plan Approach.

Section 1., Biology and Field Data, reflects our current knowledge of species in the natural environment using the most recent taxonomic information. The philosophy behind this is that ex situ conservation can be used more effectively as a conservation tool if it is part of an integrated approach to species conservation (IUCN/SSC 2014). This section provides wide and actual information about the species in its natural habitat.

Section 2., Management in Zoos, covers housing, nutrition, food presentation and environmental enrichment, social structure and behaviour. There is also useful information on introductions of chimpanzees. 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 chimpanzees 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 chimpanzee holders to get the better knowledge about keeping the species in the appropriate and best possible way. Therefore, it is recommended to regularly consult the Guidelines and contact TAG members with any concerns or queries.

Jana Pluháčková



EEP Coordinator
Ostrava Zoological
Garden and Botanical
Park
Michalkovicka 2081/197
710 00 Ostrava,
Czech Republic

Tom de Jongh

EEP Vice-coordinator
Burgers’ Zoo
Antoon van Hooffplein 1
6816 SH Arnhem,
The Netherlands

Frands Carlsen

EEP Advisor
Solbakkevej 22
2820 Gentofte
Denmark

SECTION 1. BIOLOGY AND FIELD DATA 12
1.1 Taxonomy 12
1.1.1 Taxonomic history 12
1.1.2 Present taxonomy 14
1.2 Morphological features and distinguishing characteristics 16
1.2.1 Measures 16
1.2.2 Description 16
1.3 Physiology 18
1.3.1 Body temperature 18
1.3.2 Haematological and biochemical values for blood 18
1.3.3 Blood pressure and heart rate 18
1.3.4 Respiratory rate 18
1.4 Conservation status/Zoography/Ecology 19
1.4.1 Distribution 19
1.4.2 Population 20
1.4.3 Habitat and ecology 21
1.4.4 Conservation 22
1.4.4.1 Threats 22
1.4.4.1.1 Habitat loss and degradation 22
1.4.4.1.2 Disease 23
1.4.4.2 Conservation action 23
1.4.4.2.1 Law enforcement 23
1.4.4.2.2 Land use planning 23
1.4.4.2.3 Monitoring 24
1.4.4.2.4 Outreach and awareness 24
1.4.4.2.5 Mitigation 24
1.4.4.2.6 Human chimpanzee interaction 24
1.4.4.2.7 Protected areas 25
1.4.4.3 Conservation projects endorsed by the EEP for support 25
1.5 Diet 27
1.5.1 Diversity of plant consumption 27
1.5.2 Fruits 29
1.5.3 Leaves and pith 30
1.5.4 Hunting and meat sharing 30
1.5.5 Invertebrate prey 31
1.5.6 Seasonal diet variation 32
1.5.7 Energy requirements 33
1.6. Reproduction and life history 33
1.7. Social structure and behaviour 35
1.7.1 Social structure 35
1.7.2 Behaviour 36
SECTION 2. MANAGEMENT IN ZOOS 37
2.0 Our welfare commitment 37
2.1 Enclosure (accommodations) 39
2.1.1 Boundary 39
2.1.1.1 Water moats 40
2.1.1.2 Glass barriers 41
2.1.1.3 Dry moats and walls 41
2.1.1.4 Fences 44
2.1.1.5 Mesh cages 48
2.1.1.6 Electric barriers 49

2.1.1.7 Safety distance **49**
2.1.1.8 Service access to the enclosures **49**
2.1.1.9 Barriers between the enclosures **50**
2.1.1.10 Animal doors **50**
2.1.1.11 Observation facilities **53**
2.1.2 Substrate (landscape, topography and vegetation) **53**
2.1.2.1 Substrate and floors **54**
2.1.2.2 Vegetation **57**
2.1.3 Furnishings and maintenance (incl. climbing structures) **58**
2.1.3.1 Furnishing **58**
2.1.3.2 Safety distance **59**
2.1.3.3 Climbing structures **59**
2.1.3.4 Flexible climbing material **61**
2.1.3.5 Nesting places **62**
2.1.3.6 Shelter and hiding places **63**
2.1.3.7 Water source **63**
2.1.4 Environment (indoors and the outdoors) **63**
2.1.4.1 Lighting **63**
2.1.4.1.1 UV Light *64*
2.1.4.2 Temperature **64**
2.1.4.2.1 Outside climatic conditions *64*
2.1.4.2.2 Indoor climatic conditions *65*
2.1.4.2.3 Ventilation *66*
2.1.4.2.4 Humidity *66*
2.1.4.2.5 Sound *66*
2.1.5 Dimensions **67**
2.1.5.1. Area **67**
2.1.5.2 Height **68**
2.1.6 Special features to facilitate introductions **69**
2.1.7 Facility for crate training **69**
2.2 Feeding **70**
2.2.1 Captive dietary research **70**
2.2.2 Dietary related health concerns **70**
2.2.2.1 Regurgitation and reingestion. **70**
2.2.2.2 Obesity **71**
2.2.2.3 Blood pressure **72**
2.2.2.4 Diabetes **72**
2.2.3 Captive nutrition **73**
2.2.3.1 Nutrient requirements **73**
2.2.3.2 Energy Requirements **76**
2.2.3.3 Composition of diet **76**
2.2.3.4 Current examples **76**
2.2.4 Diet reviews / monitoring **82**
2.2.4.1 Body Condition Scoring **82**
2.2.5 Feeding presentation **83**
2.2.6 Conclusion **84**
2.3 Social structure **85**
2.3.1 Basic social structure **85**
2.3.2 Social structure in captivity **85**
2.3.3 Age structure **86**
2.3.4 Changing group structure **87**

2.3.4.1 Male bachelor groups **87**
2.3.4.2 Female transfers **87**
2.3.4.3 Male transfers **88**
2.4 Breeding **89**
2.4.1 Breeding **89**
2.4.1.1 Mating **89**
2.4.1.2 Pregnancy **90**
2.4.1.3 Contraception possibilities **90**
2.4.1.3.1 Permanent (surgical) sterilization *91*
2.4.1.3.2 Reversible contraception *92*
2.4.1.3.3 Non-contraceptive effects *95*
2.4.1.3.3 Reversibility *95*
2.4.1.4 Birth **95**
2.4.1.5 Hand-rearing **96**
2.4.1.5.1 Socialisation and reintroductions: *97*
2.4.1.6 Development and care of young **98**
2.4.1.7 Assisted reproductive techniques **99**
2.4.1.7.1 Reproductive hormone monitoring: *99*
2.4.1.7.2 Gamete recovery *100*
2.5 Environmental enrichment for chimpanzees **102**
2.5.1 Environmental enrichment and the welfare of zoo chimpanzees **102**
2.5.1.1 Beauty is in the eye of the beholder: Artificial vs. natural environmental enrichments **102**
2.5.2 Food-related enrichment **103**
2.5.2.1 Foraging **104**
2.5.2.2 Browse **104**
2.5.3 Manipulative and structural enrichment **105**
2.5.3.1 Manipulative enrichments **105**
2.5.3.2 Chimpanzee enclosure **106**
2.5.4 Cognitive enrichments **106**
2.6 Handling **111**
2.6.1 Individual identification and sexing. **111**
2.6.2 General handling **111**
2.6.3 Capture/restraint and immobilisation **112**
2.6.4 Transportation **112**
2.6.5 Safety **112**
2.7 Introduction **114**
2.7.1 Advance planning stage **114**
2.7.1.1 Group factors **114**
2.7.1.2 Individual factors **115**
2.7.1.3 Facility **116**
2.7.2 Introduction stage **118**
2.7.2.1 Dyadic introductions **118**
2.7.2.2 Non-dyadic introductions **120**
2.7.2.3 Introducing familiar chimpanzees **122**
2.7.3 Managing conflict during introductions **122**
2.7.4 Summary **123**
2.8 Chimpanzee veterinary aspects **124**
2.8.1 General considerations for health & welfare of chimpanzees **124**
2.8.2 Transfer examination and diagnostic testing recommendations **124**
2.8.2.1 Minimal pre-shipment / quarantine database for chimpanzees **124**
2.8.2.3 Calming animals for transport **126**

2.8.3 Quarantine **126**
2.8.3.1 General **126**
2.8.3.2 Quarantine protocols **127**
2.8.3.2.1 Receiving facility and preparation *127*
2.8.3.2.3 Recommended quarantine examination *127*
2.8.3.2.4. Quarantine access and protective equipment *127*
2.8.4 Capture, restraint and immobilisation **128**
2.8.4.1 Precautions with anaesthesia **128**
2.8.4.2 Restraint **129**
2.8.4.3 Chemical immobilisation **129**
2.8.5 Use of neuroleptics **129**
2.8.5.1 Categories and use of neuroleptics **130**
2.8.6 Diseases of concern in chimpanzees **130**
2.8.6.1 Viruses **131**
2.8.6.2 Bacteria **131**
2.8.6.3 Fungi **132**
2.8.6.4 Parasites **132**
2.8.6.4.1 Echinococcosis *132*
2.8.6.4.2 Strongyloides, Entamoeba and Balantidium *132*
2.8.6.4.3 Diabetes *133*
2.8.6.4.4 Heart disease *133*
2.8.6.4.5 Renal failure *133*
2.8.6.4.6 Laryngeal air sacculitis *133*
2.8.6.4.7 Dental disease *134*
2.8.6.4.8 Hypothyroidism *134*
2.8.6.4.9 Vitamin D deficiency *134*
2.8.7 Bite injuries **134**
2.8.8 Neonates **134**
2.8.9 Geriatric chimpanzees **135**
2.8.10Preventative health care program **135**
2.8.10.1 Quarantine **136**
2.8.10.2 Review of medical histories and daily observations **136**
2.8.10.3 Physical and diagnostic examinations **136**
2.8.10.4 Vaccinations **138**
2.8.10.5 Nutrition **139**
2.8.10.6 Employee health program **139**
2.8.10.7 Pest control **139**
2.8.11Reproduction **140**
2.8.11.1 Pregnancy testing **140**
2.8.11.2 Contraception **140**
2.8.11.3 Non-breeding females **140**
2.8.11.3.1 Hormonal assessment *140*
2.8.11.3.2 Fertility treatment for non-ovulating chimpanzee females *140*
2.8.12Post mortem examination **141**
2.8.13Veterinary advisor contact details **141**
2.9 Specific Problems and Recommended Research **142**
2.9.1 Specific Problems **142**
2.9.2 Recommended Research **144**
SECTION 3. REFERENCES & SUGGESTED READING **146**
SECTION 4. APPENDICES **165**
4.1 Appendix I: Comprehensive guide to conducting intake studies (*cf* Bishop (2013)) **165**

4.2 Appendix II: Body Condition Scoring guide for primates 167
4.3 Appendix III: Michael Seres - The function and significance of "GAP" setting during introductions -.. 168
4.4 Appendix IV: Ape TAG Bio floor Survey for great apes in indoor enclosures. 169
4.5 Appendix V: EAZA Great Ape Taxon Advisory Group (GATAG) Hand rearing Statement 176
4.6 Appendix VI: Practical guide for the collection of urine samples from chimpanzees for monitoring female reproductive status 180

SECTION 1. BIOLOGY AND FIELD DATA

Frands Carlsen, Louise Cox (1.6) & Giuliano Matessi

1.1 Taxonomy

Class:	*Mammalia*
Order:	*Primates*
Suborder	*Haplorrhini*
Parvorder	*Catarrhini*
Superfamily	*Hominoidea*
Family:	*Hominidae*
Subfamily:	*Homininae*
Genus:	*Pan*
Species:	*troglodytes* (Blumenbach, 1775)

Scientific name explained: *Pan* from Greek meaning 'all' or 'the whole'. In Greek Mythology Pan was the rural god of Arcadia, of woods and pastures. *Troglodytes* is a composite name of the Greek words 'trogle' - a hole and 'dutes' a burrower. A troglodyte is a cave dweller

Common names: Chimpanzee, Common Chimpanzee, Robust Chimpanzee

1.1.1 Taxonomic history

Chimpanzee taxonomy has been the subject of many discussions and revisions and remains an active area of research. In 1758, Linné placed a second species in the genus *Homo* along with *H. sapiens*: *Homo troglodytes*. It is not clear to which animal this name referred. The orangutan was named *Simia satyrus*. The name *troglodytes* was used for the chimpanzee by Johann Friedrich Blumenbach in 1775 but here moved to the genus *Simia*. First recognition of a substructure in the species is attributed to Paul du Chaillu in the 1860s and consequent efforts to list different species and subspecies of chimpanzees are attributed to Gray, Reichenbach, Gratiolet & Alix, Schlegel, Giglioli, Meyer, Livingstone, Duckworth, Keith, Matschie and Rothschild amongst others. Rothschild in the early parts of the twentieth century described five different species of chimpanzees with a number of subspecies and Elliot later adopted the generic name *Pan* for chimpanzees and described the following species of chimpanzees:

- *Pan calvus* [DUCHAILLU] 1860
- *P. fuliginosus* [SCHAUFUSS] 1870
- *P. satyrus* [L.] 1758
- *P. koolakamba* (DUCHAILLU) 1860
- *P. leucoprymnus* (LESSON) 1841
- *P. chimpanse* [MAYER] 1856
- *P. schweinfurthii* [GIGLIOLI] 1872
- *P. s. marungensis* (NOACK) 1887
- *P. aubryi* [GRATIOLET and ALIX] 1866
- *P. vellerosus* [GRAY] 1862
- *P. fuscus* (MEYER) 1894-95

This comprehensive list was further built on by Matschie, proposing an additional number of species that added to the complex and somewhat confusing list with little background information to support the number of species suggested.

The simpler outline of the taxonomy of chimpanzees known today was laid down by Schwarz in 1934 (who in 1929 also named the newly discovered bonobo), recognizing just a single species, *Pan satyrus* with four subspecies, *P. s. troglodytes* from Central Africa, *P. s. verus* from West Africa, *P. s. schweinfurthii* from East Africa and present DRC north and east of the Congo River and *P. s. paniscus* south of the Congo River. The species name *satyrus* was later changed to *troglodytes* as coined by Blumenbach in 1775. The bonobo was elevated to species rank as *Pan paniscus* by Coolidge in 1933.

For more detailed information on the history of chimpanzee taxonomy see Hill (1969), Jones *et al.* (1996), Reynolds & Luscombe (1971) and Schwarz (1934)

1.1.2 Present taxonomy

The chimpanzee and the bonobo (*Pan*) are placed in the family *Hominidae* (Great Apes) together with humans (*Homo*), orangutans (*Pongo*) and gorillas (*Gorilla*) (see *Fig. 1*). According to the phylogenetic arrangement now widely accepted and supported by genetic data (Groves 2001) the family comprises two subfamilies, *Ponginae* with the genus *Pongo* and the *Homininae* with the genera *Gorilla*, *Pan* and *Homo*. Genetic data show that *Gorilla*, *Pan* and *Homo* are more similar to one another than any of them is to *Pongo*. *Homo* and *Pan* are the closest relatives and have about the same genetic distance to the gorillas (Groves 2018).

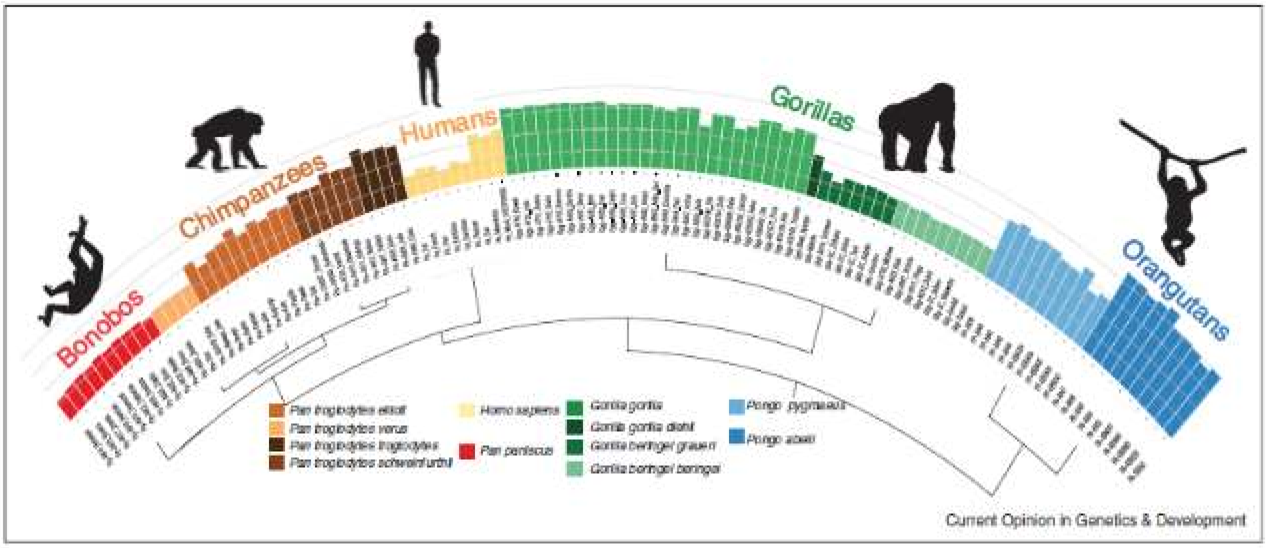


Figure 1 Phylogenetic relationships and variation of genetic diversity among the great apes. The height of the bars represents genome-wide diversity. Source: Data from Locke et al. (2011), Prado-Martinez et al. (2013), and Xue et al. (2015) were re-analysed based on sequence read mapping to their respective species reference genomes. (Taken from Kuhlwilm et al. 2016)

The nuclear DNA differs by ~1.2% between humans and chimpanzees, by 1.6% between humans and gorillas and by 1.8% between chimpanzees and gorillas. Direct estimation of the mutation rate in each of the great ape species confirms a human chimpanzee speciation time of 6.6 million years, which is consistent with *Ardipithecus* being early on the human line (and

Orrorin being ancestral to human and chimpanzee), a speciation time of 9.1 million years between humans and gorillas and a speciation time of 15.9 million years with orangutan, which is well within the time interval between the age of *Sivapithecus* (12.2 million years old) and *Proconsul* (23 million years old), which are generally assumed to be the lower and upper bounds for the human-orangutan divergence (Besenbacher *et al.* 2019).

The chimpanzee population structure is complex, which has resulted in controversy about the taxonomical status of the different subspecies. Identification using morphological traits has been used on a trial basis based on amongst other: differences in facial colour, fur length and degree of baldness in older individuals (e.g., Hill 1969; Butinsky *et al.* 2013; Williamson *et al.* 2013). These traits however show much overlap between suggested subspecies and may in some cases have been based more on differences in age (Reynolds and Luscombe 1971).

Four subspecies are commonly recognized and supported by genetic data:

Western Chimpanzee (*Pan troglodytes verus*)

Central Chimpanzee (*P. t. troglodytes*)

Nigeria-Cameroon Chimpanzee (*P. t. ellioti*)

Eastern Chimpanzee (*P. t. schweinfurthii*)

Chimpanzee taxonomy remains an active area of research. Genetic data, which include analyses of complete genomes, suggest four subspecies that form two distinctive groups: one group includes *P. t. verus* and *P. t. ellioti* and the other group includes *P. t. troglodytes* and *P. t. schweinfurthii* (Hvilsom *et al.* 2013; Prado-Martinez *et al.* 2013; Fünfstück *et al.* 2015). *P. t. verus* and *P. t. ellioti* separated from one another much earlier than *P. t. troglodytes* from *P. t. Schweinfurthii* (see *Fig. 2*).

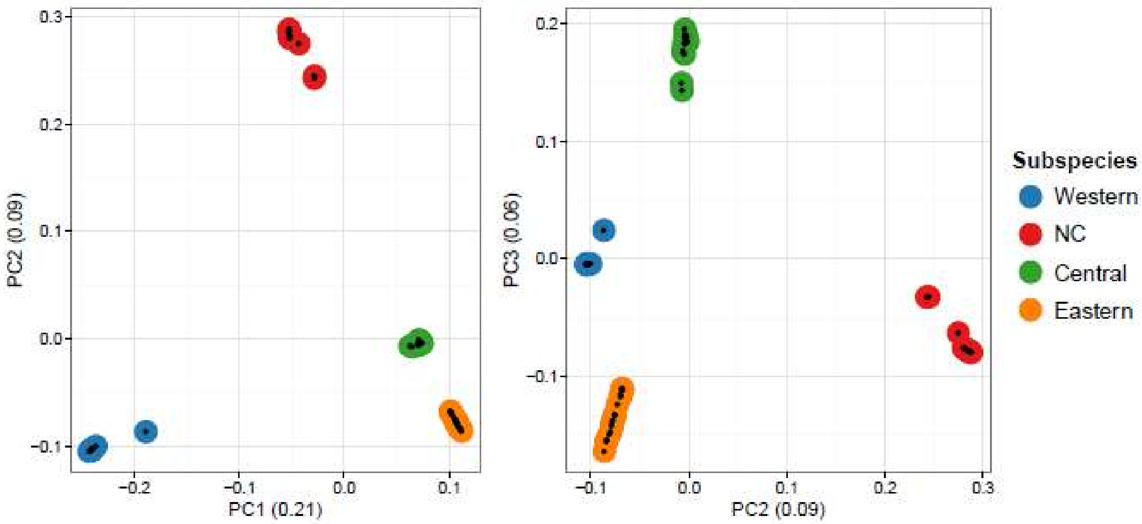


Figure 2 *PCA plot for all chimpanzee SNP data (22,081,627 SNPs). The four taxonomically recognized chimpanzee subspecies are clearly separated. Colours represent: Green; central chimpanzee. Orange; eastern chimpanzee. Red; Nigeria-Cameroon chimpanzee. Blue; western chimpanzee. (Taken from de Manuel et al. 2016)*

The degree of connectivity between chimpanzee populations in western Nigeria and those in eastern Nigeria and western Cameroon has yet to be adequately examined. Published relationship trees based on the analysis of mitochondrial DNA do not group western Nigerian chimpanzees closely with those of either Upper Guinea or eastern Nigeria (Gonder *et al.* 2006); however, those analyses were based on a very small number of western Nigerian samples. A more comprehensive analysis using additional samples is urgently needed and under way (Humle *et al.* 2016). Preliminary studies show that the SW Nigerian samples cluster separately but with closest resemblance to *P. t. ellioti* (C. Hvilsom, personal comment).

The Nigeria-Cameroon subspecies was initially described by Gonder and Oates (1997) as *P. t. vellerosus* but later more aptly named *P. t. ellioti* by Oates *et al.* (2009).

A suggestion that the Western chimpanzee (*P. t. verus*) should be ranked as a full species (Morin *et al.* 1994) has not been supported.

Groves (2005) based on craniometric studies also argue for a fifth subspecies, *P. t. marungensis*, thus subdividing what is presently *P. t. schweinfurthii* into two sub-populations – *P. t. schweinfurthii* to the northeast and *P. t. marungensis* to the southeast. Studies from Gonder (2011) do not support this claim.

1.2 Morphological features and distinguishing characteristics

1.2.1 Measures

Chimpanzees are sexually dimorphic in size, with males generally larger and heavier than females. Males in the wild weigh between 28 kg and 70 kg, and females between 20 kg and 50 kg. Head-and-body length ranges between 77 cm and 96 cm for males and 70 cm and 91 cm for females (Williamson *et al.* 2013).

The central subspecies of chimpanzee tends to be larger than the others, with male head-and-body lengths between 81.9 cm and 91.4 cm and more than 50 kg of weight, and female head-and-body lengths between 79.6 cm and 87.1 cm and between 40 and 50 kg of weight. Both sexes of the other subspecies weigh less on average, but at the same time variation within subspecies is greater than between them (Butinsky *et al.* 2013; Caldecott & Miles 2005; Williamson *et al.* 2013).

1.2.2 Description

Chimpanzees have thickset bodies, with arms longer than legs (intermembral index >100, as opposed to ~100 in bonobos), no tail and a short neck on broad shoulders. The head has prominent brow ridges, low forehead, deep set eyes and a broad and flat nose. The face is bare, like the fingers, toes, hand palms and foot soles. Facial skin is pale pink in infants, and becomes more blackish as the individual grows, and is often almost black in adults, with some variation between subspecies and individuals. The fur is long, sparse and coarse; the colour is generally black or dark brown, but grey individuals do also occur. Mature adults may have a white beard on the chin, and infants have a white tail tuft. In chimpanzees both thumbs and big toes are opposable, which allows precision grip and manipulation with hands and feet. The outer skin on the middle fingers is thickened due to quadrupedal locomotion patterns (Butinsky *et al.* 2013; Jones *et al.* 1996, Nowak 1999; Williamson *et al.* 2013).

Morphological traits are not a unique way to separate chimpanzee subspecies since there are overlaps between the different taxa and the differences are often very subtle and difficult to employ even for experts. The content in the following section should therefore be used with care and not as an absolute guide to differentiation. For this, molecular genetics are needed.

The following description of sub-specific variation is based on information from Butinsky *et al.* (2013) and Williamson *et al.* (2013):

P. t. verus: Also known as the masked chimpanzee – young individuals have a pale, skin-coloured face with darker, bluish coloration around the eyes and over the bridge of the nose (mask), which develops quickly. The hair on the crown has a median parting, which expands as a bald frontal triangle (males) or a straight line (females) with age. The facial skin darkens and becomes more blotched with age and eventually turns a dull black but the mask is still evident. Ears, large and prominent, never turn totally dark. Adult males develop a white beard. Palms and soles pale with irregular patches of darker pigmentation on digits.

P. t. ellioti: The Nigeria-Cameroon chimpanzee was formerly included in the western subspecies but was resurrected by Gonder *et al.* (1997), first as *P. t. vellerosus*, which was later discarded in favour of *P. t. ellioti*. There's only limited information on morphological differences related to other subspecies but smaller ears close to head and possibly a thick fur are mentioned as well as top of head rounder, brow ridge straighter and more gracile build (compared to *P. t. verus*). Recent analyses of chimpanzee teeth and skulls also reveal that the Nigeria-Cameroon chimpanzees have smaller teeth and skulls than surrounding chimpanzee populations. Face, feet and hands uniformly black in adults (Oates 2011).

P. t. troglodytes: The central chimpanzee is generally larger than the other subspecies. The head is broad with a concave facial profile. Ears small to medium. The pale facial skin becomes freckled with tan spots and darkening to a deep black with maturity. Ears, palms and soles also uniformly brown or black in adults. The beard is white and long. Sideburns are also long and hang downward. Scalp has thin hair from early age and individuals become bald with age. Brow ridge runs straight across.

P. t. schweinfurthii: Generally, slightly smaller than other subspecies (although variation with very large individuals found in the Bili region of DRC. The head of the eastern subspecies is rounder than in other subspecies and brow ridges are thinner and run straight across, while the lower face is narrow, and the facial profile is fairly straight and longer than *P. t. verus*. The hair is dark and long and exceedingly dense, and the beard is full but straggly. The facial skin becomes dark (bronze or coppery, but not black) in adults. Palms and soles usually also bronze or coppery.

1.3 Physiology

1.3.1 Body temperature

Using non-invasive measurements of body temperature of wild chimpanzees, Jensen *et al.* (2009) found an average temperature of 37.2 °C. Melis *et al.* (2012) found rectal temperatures ranging between 32.1 °C and 37.6 °C, with a mean value of 35.9 °C.

1.3.2 Haematological and biochemical values for blood

Howell *et al.* (2003) published haematological and serum clinical values from 86 individual chimpanzees at the Primate Foundation Arizona, across a 10-year period. Tables with values for four age categories of chimpanzees (infants 0-3.9 years, juveniles 4-6.9 years, adolescents 7-9.9 years, adults 10 years and older) are presented in their publication.

1.3.3 Blood pressure and heart rate

With heart disease as a common cause of death in chimpanzees in zoos, these are important values to monitor. Unfortunately, it has so far not been possible to determine these values in a statistically meaningful way in conscious animals. Atencia *et al.* (2017) report on such values from 220 completed health checks, of which 44 had to be excluded from analysis. This concerned chimpanzees from three different chimpanzee sanctuaries for which four different anaesthetic protocols were used. The results show that the different protocols have different effects on the values and that the values during each anaesthetic procedure and for all protocols progressively declined. Neither mean data collected over the course of an anaesthetic procedure, nor single point assessments during a procedure can be used to confidently characterize blood pressure in individual chimpanzees. Nor can the results be regarded as a good reflection of the prevailing cardiovascular health of the individual. It also turned out that the arousal from the darting or, although less, from hand injection affects the values found. The development and possible wider application of non-invasive methods to take these values through training may in the future produce more reliable values for monitoring the cardiovascular health of the chimpanzees and for establishing control values.

Meanwhile, individual collections may derive their own standard blood pressure reference ranges for the animals in their care if anaesthetic and health check protocols can be kept constant (see also *2.2.2.3 Blood pressure* and *2.8.6.4.4 Heart disease*).

1.3.4 Respiratory rate

Normal resting respiratory rates for chimpanzees do not exist to our knowledge. Kearns *et al.* (2000) report respiratory rates for 7 individuals under anaesthesia with a range of 24 +/- 6.5 breaths per minute.

1.4 Conservation status/Zoography/Ecology

1.4.1 Distribution

Chimpanzee distribution is wide but discontinuous, and ranges across sub-Saharan Africa (13° N – 7° S), between southern Senegal and Guinea in the west and the western borders of the United Republic of Tanzania in the east. Chimpanzees occur at altitudes from sea level to 2800 m a.s.l (Humle *et al.* 2016). Across this range, the different subspecies occupy separate, but in some cases overlapping, ranges (see *Table 1* and *Fig. 3*). The distribution of the different subspecies, summarized here, is described and illustrated in detail in Caldecott & Miles (2005).

Native range: Angola; Burundi; Cameroon; Central African Republic; Congo Brazzaville; Democratic Republic of Congo; Côte d'Ivoire; Equatorial Guinea; Gabon; Ghana; Guinea; Guinea-Bissau; Liberia; Mali; Nigeria; Rwanda; Senegal; Sierra Leone; South Sudan; Tanzania; Uganda

Possibly extinct: Benin; Burkina Faso; Togo

Regionally extinct: The Gambia

Table 1 Chimpanzee taxonomy presently recognized with geographical range

Scientific name	Common name(s)	Range
P. t. troglodytes	Central chimpanzee Lower Guinea chimpanzee	From Cameroon, south of the Sanaga River, to the Congo River/Ubangi River (Democratic Republic of Congo)
P. t. schweinfurthii	Eastern chimpanzee Long-haired chimpanzee	From the Ubangi River/Congo River in Central African Republic and the Democratic Republic of the Congo, to western Uganda, Rwanda and western Tanzania (with small, relict populations in Burundi and south eastern Sudan)
P. t. ellioti	Nigeria-Cameroon chimpanzee Elliot's chimpanzee Gulf of Guinea chimpanzee	Nigeria and Cameroon, north of the Sanaga River to Dahomey Gap (?)*
P. t. verus	Western chimpanzee Upper Guinea chimpanzee	West Africa from Senegal to Dahomey Gap (?)*

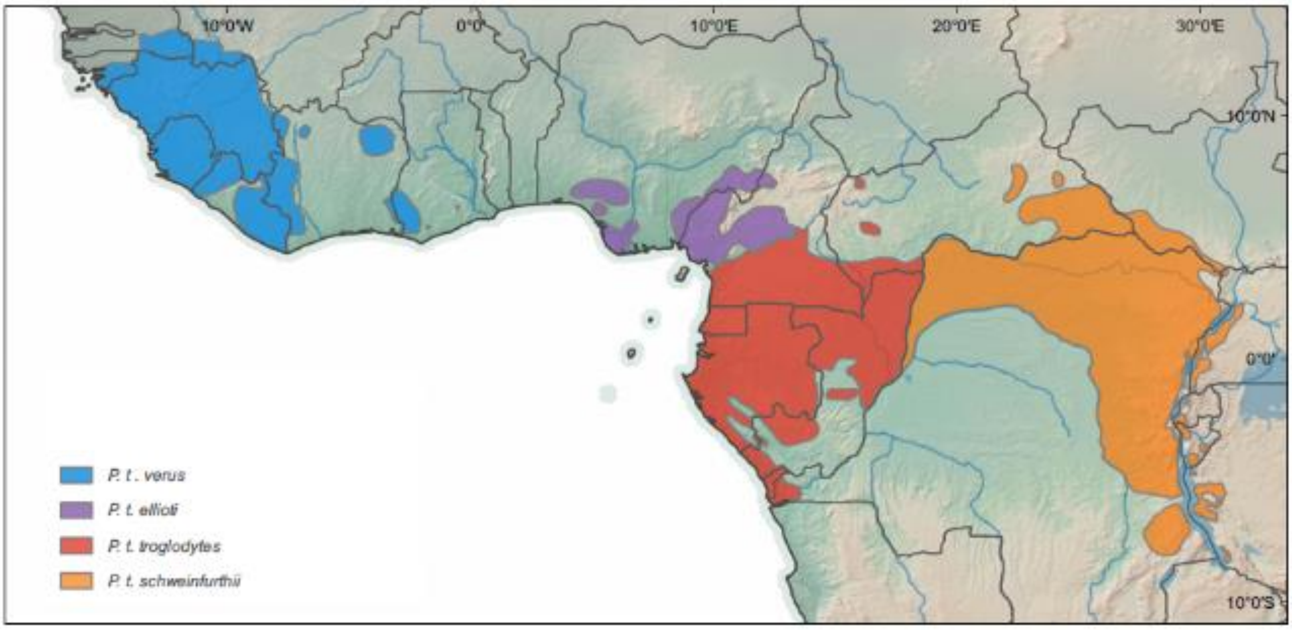


Figure 3. Geographical range of the four recognised subspecies of chimpanzees (Frandsen et al., 2020).

1.4.2 Population

Total and local chimpanzee population sizes are difficult to estimate accurately, due to both the habitat used by the animals and the socio-political situation of the countries involved. Population trends are likewise difficult to assess, although the general indications from the available data are of a steady decline across the range and with few exceptions. The IUCN Red list offers the following overview of the most recent estimates for the four subspecies:

- Endangered (EN), probably fewer than 6,000–9,000 *P. t. ellioti* (Morgan *et al.* 2011, Oates pers. comm. 2015)
- Endangered (EN), 181,000–256,000 *P. t. schweinfurthii* (Plumptre *et al.* 2010a), including a large population in northern DRC that was formerly considered to be outside of the species' known range (Hicks *et al.* 2014)
- Endangered (EN), approximately 140,000 *P. t. troglodytes* (Strindberg *et al.* in prep.)
- Critically Endangered (CR), 18,000–65,000 *P. t. verus* (Sop *et al.* in prep.)

This gives an overall estimate for the species of 345,000-470,000 and a current population trend of "decreasing". For more detailed information, see subspecies accounts at the IUCN Red list (Humle *et al.* 2016) as well as GRASP(GRASP & IUCN 2018).

*The taxonomic and demographic status of the South-west Nigerian population is uncertain. Recent studies and preliminary genetic results suggest that they may be distinct from any of the four subspecies with closest resemblance to *P. t. ellioti* (C. Hvilsom pers. comm.). This population is in serious danger of local extinction (Beck and Chapman 2008; Greengrass 2009).

1.4.3 Habitat and ecology

Chimpanzees can live in a wide variety of habitats across their range. The presence of tree cover is necessary for feeding and nesting, but otherwise the suitable habitats go from humid evergreen forests, forest mosaic, mosaic woodlands and deciduous forests, to dry savannah woodlands and even agricultural and disturbed landscapes (Williamson *et al.* 2013; Chapman and Peres 2001, van Leeuwen *et al.* 2020). Montane forests, tropical rain forests, swamp forests, subalpine moorland and open grasslands with trees are also suitable chimpanzee habitats. Chimpanzees are tolerant to habitat disturbance and will occupy logged forests and cultivated landscapes as long as patches of woods with fruit trees (especially figs) are accessible and also adapting to eating human crops (Bryson-Morrison *et al.* 2016). It still remains to be seen though, if the adaptation to agricultural mosaics is sustainable long-term or if this is just a short-term phenomenon.

Chimpanzees can adapt to a wide range of humidity and precipitation patterns, finding alternative sources of water in very dry savannahs or well-drained volcanic soils, and spending more time in trees in damp forests during the rainy season (Takemoto 2004). Nests are normally built in trees, but some populations have been observed using caves for resting in the daytime, possibly to avoid the intense heat (Pruetz 2007). Chimpanzee habitat can range in altitude from sea level, mainly in the west of the distribution, to high mountains. The maximum elevation at which each subspecies has been confirmed is ca 2,000 m a.s.l. for *P. t. ellioti*, 2,790 m for *P. t. schweinfurthii*, 742 m for *P. t. troglodytes*, and 1,607 m for *P. t. verus* (Williamson *et al.* 2013).

Chimpanzees are diurnal and both terrestrial and arboreal, with the amount of time spent on the ground varying between study sites and between sexes. Activity budgets also vary between sites: 43-55% feeding; 12-14% travelling; 25-39% resting (Williamson *et al.* 2013). They forage over a distance of 1.5-15 km and peaks of activity occur early morning and late afternoon.

All chimpanzees, except infants, build sleeping nests in trees at night. In some areas these can also be placed directly on the ground. Nest height varies from ground level to more than 40 meters, but most nests are built 10-20 meters over ground level. Nests are normally only occupied for one night but occasionally may be reused. Most travel takes place on the ground and the most common means of locomotion is quadrupedal. Chimpanzees are also capable of bipedal walk over longer distances with toes turned inward.

Annual home ranges are smaller in mixed forest than in woodland forest mosaics: one of the smallest known is 6 km^2 at Budongo in Uganda (Newton-Fisher 2003), while one of the largest is 72 km^2 at Semliki, also in Uganda (Samson and Hunt 2012).

1.4.4 Conservation

The following extract from the IUCN Red List gives an overview of the major threats and the conservation actions in place at the species level. For full text, including subspecies, see: http://www.iucnredlist.org/details/15933/0

1.4.4.1 Threats

Humans and occasionally leopards (*Panthera pardus*) are the main predators of chimpanzees. To a lesser extent, lions (savannah chimps), crocodiles and pythons can be natural predators.

The four chimpanzee subspecies face similar threats, but to varying degrees in different regions. The major threats are poaching and illegal trade, hunting as retaliation for crop damage and the bi-trade for pets, habitat loss and degradation and disease.

Poaching is the greatest threat to most chimpanzees. Due to their low population densities and slow reproductive rates, hunting often leads to the local extirpation of chimpanzee populations. Chimpanzees are generally hunted opportunistically but are sometimes targeted because they provide more meat than smaller mammals. When chimpanzees are killed for meat, their infants sometimes become pets, and some are trafficked (e.g. Hicks *et al.* 2010). In the last quarter of a century, however, almost all *terra firma* forest in the non-protected areas of the central chimpanzee's range has been assigned as logging concessions (Global Forest Watch 2016). This means that most of the once-remote, previously inaccessible forests are now covered by a network of logging roads (Laporte *et al.* 2007), which provides rapid access to hunters.

1.4.4.1.1 Habitat loss and degradation

The conversion of forest to farmland across Africa has severely reduced the availability of chimpanzee habitat. Such habitat loss is especially acute in West Africa, where it is estimated that more than 80% of the region's original forest cover had been lost by the early 2000s (Kormos *et al.* 2003). Ongoing rapid growth in human populations is expected to lead to further widespread conversion of forest and woodland to agricultural land. Logging generally has a negative impact on chimpanzee densities due to habitat alteration (principally removal of important food trees) and disturbance (Morgan *et al.* 2007). As timber concessions undergo repeated cycles of logging, degradation over time will lead to profound changes in forest composition (Zimmerman and Kormos 2012). Mining of precious metals and mineral ores, and drilling for oil not only devastate wildlife habitat, but typically also lead to human immigration and the building of roads, railways and other infrastructure. As with logging, the resulting increased accessibility to remote areas exacerbates risks to chimpanzees through habitat degradation and fragmentation in areas not previously impacted by such anthropogenic pressures. As tropical Asia nears its capacity for oil-palm plantations, Africa has become the new frontier for this crop, which offers excellent economic prospects in countries with appropriate rainfall, soil and temperature conditions (Rival and Lavang 2014). Unfortunately, these areas coincide with good great ape habitat: 42.3% of the African apes' range is suitable for oil palm (Wich *et al.* 2014). This situation is of special concern for chimpanzees living outside protected areas. Major transportation infrastructure will substantially fragment great ape habitat and add further to the area of "lost forest" (Laurance *et al.* 2015).

1.4.4.1.2 Disease

Because chimpanzees and humans are so similar, chimpanzees succumb to many diseases that afflict humans. Infectious diseases, including outbreaks of respiratory disease and anthrax, are the main cause of death in several chimpanzee populations that have been habituated to human presence (e.g. Goodall 1986; Nishida *et al.* 2003; Hanamura *et al.* 2006; Leendertz *et al.* 2006; Köndgen *et al.*2008; Humle 2011). If not properly managed, research and tourism present opportunities for disease transmission between humans and chimpanzees (Gilardi *et al.* 2015). The second major driver of decline in central chimpanzee populations is infectious disease, especially Ebola virus disease (EVD).

1.4.4.2 Conservation action

Pan troglodytes is listed on Appendix I of CITES and as Class A under the African Convention on the Conservation of Nature and Natural Resources. Chimpanzees are protected by national and international laws throughout their range, but enforcement is generally weak. All four subspecies occur in numerous national parks; however, the majority occur outside protected areas (IUCN SSC A.P.E.S. database 2016).

Even within protected areas, safe haven is not guaranteed: many protected areas in tropical Africa lack adequate management and suffer from poorly-controlled poaching. Stricter enforcement of wildlife laws and more effective management of what may become the last refuges for many great ape populations are needed urgently.

Conservation needs for chimpanzees across Africa fall into several broad areas:

1.4.4.2.1 Law enforcement

Effective law enforcement, not only in protected areas, but also in logging, mining and agricultural concessions. Chimpanzees are protected by legislation even where the land is not protected.

1.4.4.2.2 Land use planning

Effective, coordinated land-use planning across the geographic range of the species to avoid the clearing of large areas of chimpanzee habitat to establish large-scale agriculture, especially oil-palm plantations (IUCN SSC Primate Specialist Group 2014; Wich *et al.* 2014; Ruysschaert and Rainer 2015). Industrial extraction of other natural resources, namely timber and minerals, should be incorporated into a holistic, spatially-explicit approach. Such planning needs to be done at both national and regional levels.

Several of the most important areas for chimpanzee conservation are transboundary, and thus fall within the remit of national agencies from two or three countries.

1.4.4.2.3 Monitoring

Long-term standardised monitoring of law enforcement efforts and effectiveness, of chimpanzee abundance throughout their range, and of chimpanzee health. A standardised tool for law enforcement monitoring (SMART: www.smartconservationsoftware.org) is already in use across much of the range; standard methods for surveying and monitoring great ape populations that facilitate more accurate and precise monitoring of changes in abundance have been recommended for almost a decade (Kühl *et al.* 2008 www.primate-sg.org/best_practice_surveys); and non-invasive diagnosis of a range of pathogens is now possible, for example, detection of Ebola virus in faeces (Reed *et al.* 2014).

1.4.4.2.4 Outreach and awareness

Outreach to and awareness-raising among all sectors that deal with land and the protection of natural resources: law enforcement and judiciary; protected area authorities; mining, logging, and agricultural industries; local communities and tour operators. This effort should include information on minimising human impacts, such as avoidance of disease transmission to great apes. Recommendations for logging companies regarding management practices that are compatible with great ape conservation (Morgan and Sanz 2007, Morgan *et al.* 2013) are available for download: www.primate-sg.org/best_practice_logging

1.4.4.2.5 Mitigation

Further research into ways of mitigating the spread and virulence of Ebolavirus, including means of administering vaccines that are non-detrimental to the target species (great apes) and other species that may come into contact with the vaccine, and that will protect a sufficiently large and geographically-appropriate proportion of the great ape population to form a barrier against its spread. Disease prevention guidelines (Gilardi *et al.* 2015) are available at: www.primate-sg.org/best_practice_disease

1.4.4.2.6 Human chimpanzee interaction

Better understanding of the interactions between people and chimpanzees, and involving local stakeholders in participative management, especially outside or at the periphery of protected areas.

1.4.4.2.7 Protected areas

Maintaining large, well-protected areas of forest will be the key to maintaining chimpanzee populations in the long term, and this can only be done by a combination of the actions detailed above. The IUCN SSC Primate Specialist Group has published regional conservation action plans for each subspecies of chimpanzee. The most recent of these documents are Kormos *et al.* (2003), Plumptre *et al.* (2010a), Morgan *et al.* (2011) and IUCN (2014); all are available for download at: www.primate-sg.org/action_plans

1.4.4.3 Conservation projects endorsed by the EEP for support

Initially, efforts were focused on support for Western chimpanzees (*Pan troglodytes verus*) in Sierra Leone, as a large number of founders in the European population originated from this country. In the conclusion on Sierra Leone, The IUCN/SSC Regional Action Plan for the Conservation of chimpanzees in West Africa (Kormos *et al.* 2003) states an urgent need for international support to strengthen the capacity of local NGOs and the specific need that Tacugama Chimpanzee Sanctuary (TCS) should be given full recognition as a valuable asset to chimpanzee conservation in Sierra Leone. On this basis TCS was the first focus for support endorsement from the chimpanzee EEP and since 2008 several EAZA institutions have supported the effective conservation work of TCS.

In time with the development of the programme, including breeding efforts for additional subspecies, the need for endorsement of projects from other regions has evolved leading to the need for a broader focus.

Numerous organisations and individuals work to protect wild chimpanzee populations from extinction. Several chimpanzee holding institutions in EAZA support specific projects selected based on historical affiliations with countries/regions/organisations/individuals.

The EEP supports this approach and in addition, in order to facilitate conservation support from institutions without such links, has created a list of EEP endorsed projects/ organisations with the assistance of the EEP Conservation Advisor based on the initial vision that:

- It should be well-run projects over geographic range of the species in order to offer choice
- If possible, list should consider all subspecies
- It should be projects that are not already heavily funded from other sources
- Priority should be based on threats, long term field presence, geographic balance etc.
- Assessment based on needs and performance of the implementing partner
- Intervention (law enforcement, ecotourism development, PA management, community engagement, research, land use planning, etc.)
- Holistic approach preferred

For lists of projects and organisations already receiving support from EAZA institutions, retrieved from the EAZA Conservation Database, please visit:

https://eaza.sharepoint.com/sites/member/tag/greatape/Chimpanzee%20documents/Conservation/Chimpanzee%20in%20situ%20projects%20supported%20byt%20EAZA%20institutions.pdf

For a list of EEP endorsed projects/organisations please visit:

https://eaza.sharepoint.com/sites/member/tag/greatape/Chimpanzee%20documents/Conservation/Chimpanzee%20EEP%20endorsed%20in%20situ%20conservation%20projects.pdf

1.5 Diet

Chimpanzees have been defined as frugivores due to their dependence on fruit (Wrangham, 1977), however they also consume piths, seeds, bark, flowers, insects and mammals which suggests this terminology is not truly reflective of chimpanzee diets (Tutin *et al.* 1997). Wild adult chimpanzees spend a significant amount of time (22.5%-30.7%) during the day feeding and foraging (Bogart and Pruetz 2011; Hockings, Anderson and Matsuzawa 2009). Many studies have examined the number of different species eaten by chimpanzees to describe wild diets and feeding ecology, as well as looking at time spent feeding on certain food groups. Whilst this shows the breath and diversity of chimpanzee diets, it does not provide nutrient composition of the diets and assumes all food items are of equal importance to the chimpanzees (Cabana, Jasmi and Maguire 2017; Tutin *et al.* 1997). Quantifying the amount of each food item consumed would provide more accurate reports of chimpanzee diets, although this is often impractical (Cabana, Jasmi and Maguire 2017; Tutin *et al.* 1997).

1.5.1 Diversity of plant consumption

The majority of chimpanzee diets have been described as containing predominantly fruits, and it appears chimpanzees actively search for particular fruits to eat (Dutton and Chapman, 2015; Moscovice *et al.* 2007; Basabose 2002) rather than eating what is most available. The number of different plant species consumed ranges from 46 to 179 (*Table 2*). It is likely that not all plant species eaten are observed during these studies, due to limitations of methods whereby macroscopic faecal analysis is unlikely to accurately identify all leaf and species (McGrew, Baldwin and Tutin 1988). Whilst chimpanzees consume many species, a large proportion of the diet is made up from a few foods, for example Watts *et al.* (2012a) found the most common 15 foods were eaten for 77.1% of the time, and Dutton & Chapman (2015) found 94% of faeces contained just 14 species. Similarly, Thompson and Wrangham (2008) discovered chimpanzees spent 56.2% of feeding time, and 82.5% of fruit feeding time, on the top 7 fruits. Piel *et al.* (2007) found only 9 (13%) plant species were identified as key plant foods, defined as being found in >50% of faecal samples in any one month, and only 4 (*Ficus* spec., *Garcinia hulliensis, Saba comorensis* and *Grewia rugosifolia*) of these were seen in >50% faeces in two months (Piel *et al.* 2017). Therefore, whilst chimpanzees have a large repertoire of foods, only a small number are consumed frequently. The nutrient composition of foods consumed by wild chimpanzees is high in fibre and low in water soluble carbohydrates and lipids (*Table 3*).

Table 2: Diversity of plant foods in wild chimpanzees.

Chimpanzee taxon	Location	Number of plant species eaten	Number of fruit species	Reference	Plant parts/food items
Pan troglodytes troglodytes	Gabon	132	111	Tutin and Fernandez 1993	161
Pan troglodytes schweinfurthii	Democratic Republic of Congo	110 + 4 unidentified species	66	Basabose, 2002	156
Pan troglodytes schweinfurthii	Uganda	102	N/A	Watts *et al.* 2012a	167 + 24 unidentified items
Pan troglodytes schweinfurthii	Tanzania	69	N/A	Piel *et al.* 2017	N/A
Pan troglodytes verus	Senegal,	43 + 41 unconfirmed species	34 fruit parts	McGrew, Baldwin and Tutin 1988	60
Pan troglodytes ellioti	Nigeria	N/A	52 (fruit taxa) 22 known at species level	Dutton and Chapman 2015	75
Unspecified	Tanzania	46	43	Moscovice *et al.* 2007	46
Pan troglodytes verus	Guinea-Bissau	66	53	Bessa, Sousa and Hockings 2015	83
unspecified	Democratic Republic of Congo	104	59	Yamagiwa and Basabose 2009	137
Pan troglodytes schweinfurthii	Uganda	179	63.5%	Bray *et al.* 2017	111
Pan troglodytes verus	Guinea	140 (123 wild, 7 cultivated)	N/A	Hockings, Anderson and Matsuzawa 2009	212 (188 wild and 24 cultivated)

Table 3: Nutrient composition of foods eaten by chimpanzees (table from Wrangham, Conklin-Britain and Hunt, 1998).

	% Dry Matter					
	Ripe fruit	Unripe fruit	Leaf	Seed	Pith	Flowers
Lipid	4.9	3.1	1.4	8.4	1.3	2.5
Crude Protein	9.5	12.0	22.1	14.3	11.1	20.8
Water soluble carbohydrates	13.9	8.0	5.3	9.8	11.0	8.5
NDF	33.6	38.7	40.7	46.1	40.0	35.5
ADF	23.8	27.1	27.5	30.7	26.7	24.5

1.5.2 Fruits

The majority of plant foods eaten are fruits, which are deemed the most important part of the chimpanzees' diet (Tutin and Fernandez 1993). The majority (58-98.2%) of faeces contain solely fruit (Dutton and Chapman 2015; Watts *et al.* 2012; Tutin and Fernandez 1993), and 97.9-100% of faecal samples contain evidence of at least one species of fruit (Bessa, Sousa and Hockings 2015; Yamagiwa and Basabose 2009). Additionally, Bogart and Pruetz (2011) found 60.8% of foraging time for males was spent consuming fruits and seeds. Fruit is generally consumed ripe [88% of all fruit consumption, (Bessa, Sousa and Hockings, 2015)] and Thompson and Wrangham (2008) found 68.1% of feeding time was spent consuming ripe fruits. Based on faecal samples, ripe fruits comprised 46.3-75.6% of the whole chimpanzee diet (Hockings, Anderson and Matsuzawa 2009). However, a low abundance of ripe fruit does not result in low consumption of fruits by chimpanzees (Hockings, Anderson and Matsuzawa 2009). Female chimpanzees in Cote d'Ivoire appear to alter their travelling patterns in the direction of fruits higher in fat, sugar or NDF (Ban *et al.* 2016) potentially suggesting a preference for these fruits. Liana (*Saba comorensis* var 1) fruit seems particularly important as it has been documented in 66% of faeces and is considered a fall-back food when fruit is less abundant (Moscovice *et al.* 2007). *Ficus* species (figs) have also been documented as frequently seen in the diet (Piel *et al.* 2017; Dutton and Chapman 2015; Moscovice *et al.* 2007) and suggested to be a preferred food by chimpanzees due to consistently being in 45-94% of faeces (Bassa, Sousa and Hockings 2015; Yamagiwa and Basabose 2009; Basabose 2002). Figs have also been found in 90% of months (Piel *et al.* 2017) even when other fruits were readily available. Hockings, Anderson and Matsuzawa (2009) studied the rate chimpanzees crop raid on sugary fruits (such as melon, papaya, banana, orange and pineapple), maize, cacao and cassava tuber amongst others. Predictably, chimpanzees raided crops most frequently when fruits in the forests were least abundant, however, the rate of crop raiding was not significantly influenced by the abundance of sugary fruits; potentially suggesting chimps do not seek out sugary fruits but use them as fall-back foods (Hockings, Anderson and Matsuzawa 2009). The type of fruits available can have an impact on mating as Thompson and Wrangham (2008) discovered females were more likely have maximum swellings when drupe (single seed surrounded by a fleshy outer part) fruits were more abundant compared with fig fruits. Additionally, more female chimps conceived when drupe fruits were available, suggesting that access to preferred fruits could increase ovarian performance (Thompson and Wrangham 2008). Chimpanzees live in various habitats whereby the foods available differ in nutritional composition. For example, Hohmann *et al.* (2012) found fruit samples in Ngogo National Park, Uganda to be higher in protein and lower in sucrose than fruits from Tai National Park, Cote D'Ivoire. However, fibre levels were similar across the different sites sampled, as was the energy available from fruits (ranging 18.2-20 KJ/g DM) (Hohmann *et al.* 2012). Leaves were found to contain more protein than fruits, although rarely eaten by chimpanzees suggesting this would have little impact on the protein content of the diets (Hohmann *et al.* 2012). However, these results could be dependent on the ripeness of different fruits when sampled (Hohmann *et al.* 2012).

1.5.3 Leaves and pith

Leaves and pith are also important food items for chimpanzees and found in 17.2-36.9% and 15.2-18.3% of faeces respectively, throughout the entire year (Bessa, Sousa and Hockings 2015; Hockings, Anderson and Matsuzawa 2009). Chimpanzees consume more leaves during periods with a low availability of ripe fruit, rather than a high abundance of leaves suggesting they use leaves as a replacement for fruit (Bessa, Sousa and Hockings 2015).

1.5.4 Hunting and meat sharing

The majority of primates do not consume vertebrate prey. Chimpanzees, however, are known to hunt vertebrates although the nutritional benefit of this is not fully understood (Tennie, Malley and Gilby 2014). Tennie, Malley and Gilby (2014) hypothesize that meat eating has a fundamental nutritional benefit which is the motivation for this behaviour. Many studies have reported chimpanzees hunting and consuming red colobus monkeys (Stanford *et al.* 1994; Boesch and Boesch 1989) which seem particularly preferred by chimpanzees as all long-term research sites with both primates have reported red colobus consumption by chimpanzees (Stanford *et al.* 1994). This is possibly because they provide a high nutritional benefit and/or require less energy to successfully hunt than other species, resulting in an evolutionary preference for red colobus (Tennie, Malley and Gilby 2014). Chimpanzees in Gombe, Tanzania were studied for hunting patterns over a 9-year period and out of 429 mammalian feeds, 82% were of red colobus monkeys (Stanford *et al.* 1994). Chimpanzees inhabiting Tai National Park, Côte d'Ivoire showed a similar preference for red colobus whereby 81% of prey were red colobus (Boesch and Boesch 1989). However, just 6.6% of chimpanzee encounters with colobus monkeys in Tai National Park resulted in a hunt, of which 31% were deemed opportunistic hunts (Boesch and Boesch 1989). This is particularly different to research at Gombe National Park, whereby 71.5% of encounters with red colobus monkeys resulted in a chimpanzee hunt, although the likelihood of hunts varied yearly (Stanford *et al.* 1994). Adult and adolescent male chimpanzees were most likely to hunt, contributing to 89.4% of hunts, and hunting frequency varied monthly with the highest frequency of hunting in the dry season (Stanford *et al.* 1994). However, these variations could be due to fluctuations in the number of males who were experienced hunters (Stanford *et al.* 1994). Red colobus monkeys are not the only chimpanzee prey, as bush pigs (10.3%), bushbuck (5.2%) and baboons (2.1%) were also consumed by chimpanzees in Gombe (Stanford *et al.* 1994) and Yamagiwa and Basabose

(2009) found evidence of *Cercopithecus* monkeys and a giant forest squirrel (*Protexerus stangeri*) in faeces from chimpanzees in Democratic Republic of Congo.

In Cote d'Ivoire, hunts seem frequent with 100 hunts observed over a 299 day observation period, equating to an average of 10 hunts per month (Boesch and Boesch 1989). However, not all chimpanzees hunt so frequently, or at all. During eight years of observations, chimpanzees in Gabon were seen to consume mammals on just four occasions, and found in 1.7% of faeces (Tutin and Fernandez 1993). Similarly, only one killing was observed within a 19-month period by chimpanzees in Tanzania where a sitatunga was consumed (Moscovice *et al.* 2007) and Deblauwe and Janssens (2008) reported chimpanzees in Cameroon consume 0.2% of the diet as meat. Additionally, 810 faecal samples collected over five years did not reveal any vertebrate prey (Piel *et al.* 2017). However, faecal samples do not provide the most accurate evidence for consumption of vertebrate prey (Bessa, Sousa and Hockings 2015) and prey consumption is probably underestimated as chimpanzees are likely to hunt opportunistically (Deblauwe and Janssens 2008). As chimpanzees often share meat, analysing meat remains in faeces is not necessarily a reliable way to assess dietary meat as it is not equivalent to assessing how often chimpanzees hunt (Moore *et al.* 2017).

Although meat sharing is rarely seen in many nonhuman primate species (Silk *et al.* 2013), meat sharing is common in chimpanzees (Moore *et al.* 2017). Meat sharing is more commonly seen in forest living chimpanzees and could be related to social status; with more dominant males more likely to share meat and are more likely to share with other males (Boesch and Boesch 1989). Captive chimpanzees have shown that food sharing may be conducted to strengthen relationships between group members, ensure food reaches related individuals, to return a food sharing event that happened previously or to end begging from other members (Silk *et al.* 2013). This research was conducted using fruit juice and peanuts, rather than meat, which may differ from the reasons for food sharing in the wild (Silk *et al.* 2013).

1.5.5 Invertebrate prey

Chimpanzees are known to eat stinging ants, termites, grasshoppers, weaver and driver ants, honeybees and beetle larvae (Piel *et al.* 2017; Bogart and Pruetz 2011; Moscovice *et al.* 2007; McGrew, Baldwin and Tutin 1988). Teeth marks, potentially suggesting chimpanzee consumption, have been found in giant African land snails (Bessa, Sousa and Hockings 2015). Tutin and Fernandez (1992) suggest that chimpanzees eat the most insects at the beginning of the dry season, with a peak in June and appear to deliberately choose to eat insects (Tutin and Fernandez 1992). This may be because they contain more protein and fat than fruit or vegetables (Rothman *et al.* 2014). However, chimpanzees in Cameroon consumed approximately 14g of insects daily equating to 1% of the daily intake, suggesting there is little nutritional benefit to consuming these insects (Deblauwe and Janssens 2008).

During seven years of research on chimpanzees in Gabon, 31.1% of faeces contained remains of at least one species of insect (Tutin and Fernandez 1992). Chimpanzees consumed at least five ant species and two bee species and weaver ants were found most often in 58% of faeces with insect remains in (Tutin and Fernandez 1992). Yamagiwa and Basabose (2009) studied chimpanzees for 92 months and found five species of insects in 5% of faeces (from 8040 samples), however focal observations saw insect feeding during 48% of observations. However, animal products do not make up a large part of all chimpanzee's diets. Analysis of 805 feeding traces from chimpanzees in Cameroon, showed 2.1% of the traces contained insects, with 82% of these being termites, 12% winged insects (alates), and 6% on *Protermes* *prorepens* (Deblauwe and Janssens 2008). Faecal samples from chimpanzees in Guinea-Bissau revealed bee wax in almost 8% of faeces (Bessa, Sousa and Hockings 2015) which is less than the 20% of honeybee products found in chimps in Gabon (Tutin and Fernandez 1992). Faecal analysis of the Eastern chimpanzee showed a relatively small percentage (9%) of the diet comprised of animal products including honey, insects and mammals (Basabose 2002). Similarly, less than 4% of faeces in Nigerian-Cameroon contained animal remains (4% contains animal, bark and 'other' items) (Dutton and Chapman 2015). Additionally, in Gabon, a large variation in frequency of insects in faeces was seen between month (16-52%) and yearly averages (8-29%) (Tutin and Fernandez 1992). As with meat consumption, invertebrate prey may be underestimated when assessing quantity through faecal samples.

Male chimpanzees in Senegal spent 7.4-19.5% of their daily activity budget termite fishing (Bogart and Pruetz 2011). Time spent termite fishing increased during the dry season (from 22.6 minutes in wet season, to 33.6 minutes in the dry season) (Bogart and Pruetz 2011). Luncz and Boesch (2015) studied neighbouring communities in Cote d'Ivoire and found one group spent 17 minutes, termite pounding, whereas two other communities have never been observed doing this, suggesting not all chimpanzee communities consume invertebrates at the same rate, nor using the same behaviours. Chimpanzees raiding ant nests also showed different behaviours with members of one community using only their hands in the nest, whereas members of another community used only their hands during 30% of raids, and the remaining time used also their arms (Luncz and Boesch 2015). Termites are unlikely to be fall-back foods as fruits and other foods were abundant, and therefore the differences observed is likely due to differences in chimpanzee cultures (Luncz and Boesch 2015). Therefore, invertebrate consumption appears to have behavioural aspects and differs between communities.

1.5.6 Seasonal diet variation

Chimpanzees live in environments with clear wet and dry seasons. The wet season provides more fruiting trees than the dry season (Uganda, Watts *et al.* 2012b; DRC, Basabose 2002; Gabon, Tutin *et al.* 1997; Guinea-Biassau, Bessa, Sousa and Hockings 2015) and so chimpanzees consume more leaves and piths (Basabose, 2002; Tutin *et al.* 1997), and fruit species (Dutton and Chapman 2015) during the dry season. However, this may vary depending on location as Moscovice *et al.* (2007) found rainfall did not affect tree or liana fruit availability in Tanzania. Liana fruits varied little across months; however, tree fruits were least abundant in the dry season (Moscovice *et al.* 2007). In Western Tanzania, the end of the dry season / beginning of wet season yielded the highest diversity of seeds (Piel *et al.* 2017). Similarly, fruit availability peaked at the start of the dry season, although the overall number of species eaten did not differ between wet and dry seasons (Piel *et al.* 2017). Ripe fruits are therefore deemed an important food in chimpanzee diets due to the increase in intake during periods of high abundance (Conklin- Brittain, Wrangham and Hunt 1998).

Seasonal variation is also seen in insect consumption, with a peak in insect consumption at the beginning of the dry season when fruits are low (Yamagiwa and Basabose 2009; Tutin and Fernandez 1992). With less fruit available in the dry season, significantly more animal foods, bark and other items were consumed by Nigerian-Cameroon chimpanzees, although the overall rate of consumption remained low (less than 4% of diet) (Dutton and Chapman 2015). This contrasts research in Senegal, which found the time-consuming termites was higher than time eating fruits in May-July (Bogart and Pruetz 2011). Furthermore, bark was observed to be eaten by chimpanzees 27 times, mostly later in the wet season when fruit abundance was low (Piel *et al.* 2017). Piel *et al.* (2017) hypothesized this is a way for chimpanzees to increase their nutritional intake when the fruit abundance is low. The dry season also increases the time chimpanzees spend feeding from the ground (Sabater-Pi 1979).

1.5.7 Energy requirements

Conklin-Brittain, Wrangham and Hunt (1998) found wild chimpanzee diets contained 215.2 +/- 42.9kcal/g. Additionally, wild chimpanzees have been estimated to consume 1806-3333kcal daily, based on high levels of fibre fermentation (Conklin-Britain, Knott and Wrangham, 2006). There was no correlation between the amount of fruit available and daily energy intake, and energy fluctuated seasonally (Conklin-Britain, Knott and Wrangham 2006). However, these intakes can only be estimates due to limitations in methodologies, for example assuming chimpanzees gain the same amount of energy from fat, protein and carbs as humans (Conklin-Britain, Knott and Wrangham 2006). Research into chimpanzee energy balance (energy intake – energy used) has shown females have a similar energy balance across periods of varying fruit availability, suggesting they are most effective at managing energy requirements, whereas males had varying energy balances throughout seasons (Ortmann and Boesch 2009). Females consistently endured individual days with a negative energy balance, although overall, all chimpanzees had a positive energy balance in all seasons, so were consuming enough to cover their basic nutritional requirements (N'guessan, Ortmann and Boesch 2009).

1.6. Reproduction and life history

Chimpanzees reproduce throughout the year. Female menstrual cycle is on average 35 days. The cycle is divided in four major phases:

- Tumescence, where sexual swelling of the anogenital area increases gradually (6 days);
- Maximal tumescence, where pink swelling is complete in size and colour and most attractive to males reaching a max around ovulation (10 days);
- Detumescence, where swelling decreases and the skin is flabby (5-6 days);
- Flat, with no swelling (14 days). Menstruation lasts 3 days and occurs some 9 days after the onset of detumescence (Jones *et al.* 1996, Nowak 1999, Caldecott & Miles 2005, Marsden *et al.* 2006; Williamson *et al.* 2013).

Mating is opportunistic and females may copulate frequently with numerous males.

Male and female chimpanzees both can reach sexual maturity at 7-8 years of age, but females normally have their first menstruation at around 10-11 years old, and give birth successfully around 13-14 years, following a period of adolescent sterility lasting 2-3 years. It is around the time of sexual maturity that females often, but not always, disperse from their natal community. Male chimpanzees, on the other hand, are philopatric and stay in their natal community. Males are not normally fully integrated in the social hierarchy, and able to consort successfully with a female until around 15 years old, where they gain most muscular mass and testicular volume (Jones *et al.* 1996, Nowak 1999, Caldecott and Miles 2005, Marsden *et al.* 2006; Williamson *et al.* 2013).

The gestation period of the chimpanzee is 7½-8 months (230-240 days on average). Females normally give birth to a single infant, with only occasional twin births. A few cases of triplets have also been observed in zoos. Twins are often born smaller and weaker (often before the end of the normal gestation period) than single infants and they put an additional strain on the mother for feeding them. In some cases, the mother will receive help from other group members to carry her young but as it is difficult for the female to take care of 2 or even 3 young, often one or more die (Kishimoto *et al.* 2014). Combining average age of female first pregnancy (13-14 years), female longevity (48 years (Nishida *et al.* 2003)) and given an average interbirth interval of 5 to 6 years (suckling inhibits post-partum cycling), females in the wild normally give birth to a total of 4-7 infants in their lifetime (Jones *et al.* 1996, Nowak 1999, Caldecott and Miles 2005, Marsden *et al.* 2006). In a study from Mahale (Nishida *et al.* 2003) the fecundity of females was highest at ages 20-35 years.

Females usually give birth at night. Labour lasts several hours during which the female is restless. From observations in the wild, females build multiple nests and give birth in an arboreal nest. The mother bites the umbilical cord and eats the placenta. Neonatal weight is estimated at 1-2.5 kg. The young clings to its mother's hair and she initially carries it ventrally and after some weeks the infants travel dorsally (Williamson *et al.* 2013).

Primates and great apes specifically have a prolonged period of immaturity. The developmental stages of chimpanzees are generally divided into four distinct phases: infancy/juvenility/adolescence/adulthood based not only on physical development but also behaviour and social maturity (Goodall 1983; Matsumoto and Hayaki 2015) potentially adding a fifth, neonate state from 0-3 months of age. Infancy ends with weaning and return of mother's oestrus (around 3½-4½ years of age). The juvenile chimp is able to move around and climb independently of its mother (though may not necessarily be totally independent) and able to build own nest and sleep alone. Adolescence is characterised by sexual maturity and occurs at around 8-9 years of age. Adulthood is characterised by both physical and social maturity and occurs at an age of 13-16 years.

Chimpanzees in the wild can reach 40 to even 50 years of age, but on average life spans are shorter. Females can remain fertile until at least 40 years old, and possibly longer. Males may have slightly lower longevity than females (Goodall 1986, Carey and Judge 2000; Williamson *et al.* 2013). A few chimpanzees have allegedly reached ages of 60+ years. Life spans in zoos are longer than in the wild in general and especially females reaching ages over 50 here are not uncommon.

In a demographic study from Mahale (Nishida *et al.* 2003) the major cause of death was disease (48%) followed by senescence (24%) and intraspecific aggression (16%) and a high infant mortality at around 50%. The deaths listed as being caused by senescence are not listed with underlying death causes.

The most important cause of mortality in the Kasekela community of Gombe National Park (Williams *et al.* 2008) was illness (58% of deaths with known cause), followed by intraspecific aggression (20% of deaths with known cause).

1.7. Social structure and behaviour

1.7.1 Social structure

Chimpanzees form bisexual social units or communities comprising multiple males and multiple females of various ages including their offspring. Females transfer between communities at sexual maturity while males remain in their natal communities, maintaining a male philopatric system, and thus avoiding inbreeding.

Chimpanzees live in so-called fission-fusion communities, in which a core of related males patrol the community boundary. Community size ranges from ~20 to ~150 individuals, with only one community larger than 100 individuals (Mitani 2006, Newton-Fisher 2002, Sugiyama 2004, Goodall 1986, Wrangham 2000, Nishida *et al.* 1985, Nishida *et al.* 2003, Boesch & Boesch-Achermann 2000, Gagneux, Boesch and Woodruff 1999). All members regularly associate with each other but also split up in smaller parties for shorter or longer period of time. Party sizes (4 to 10 individuals) change quickly and are unpredictable except for females with immature offspring (Goodall 1986, Chapman *et al.* 1993, Boesch 1996, Furuichi 2009, Sakura 1994, Boesch and Boesch-Achermann 2000, van Lawick-Goodall 1968, Nishida 1968). Party size increases with availability of oestrus females and changes also with food availability and type of food with smaller parties when foraging in the canopy or using tools (ants and termites). Parties can consist of one or both sexes as well as different age classes. This system makes it easier to exploit resources of various sizes, seasons, and locations within the community's home range and size and composition of parties is influenced by the threat of predators, including humans, the presence of other mammal species and the availability and distribution of water and nesting sites as well as food abundance (Caldecott and Miles 2005). Bisexual parties usually contain more males than females. Community home range sizes vary with community size and habitat – especially between forest/ woodland on one side and savannah on the other. In the former estimated range sizes are 7-32 km^2 with an average of 12 km^2, while in the latter, they often exceed 65 km^2. Community size range is 15-80, averaging 35 (Nowak 1999; Williamson 2013).

Interactions with other communities can be extremely hostile and occasionally result in fatalities. Despite the labile nature of chimpanzee parties, male chimpanzees are typically more social than females (Goodall 1986; Newton-Fisher 1999). Males are usually found with females in mixed parties, whereas females often range alone with their offspring or in small parties with other females (Caldecott and Miles 2005). Male sociality predisposes them to affiliate and cooperate in several behavioural contexts. They form stable subgroups, of individual males that over a longer period maintain closer bonds to each other than to other community members (Mitani and Amsler 2003). As noted previously, male chimpanzees spend considerable time grooming each other and are well known for forming short-term coalitions in which two individuals join forces to direct aggression toward third parties. Males also hunt together, share meat, develop long-term alliances to improve their dominance rank, and communally defend their territories during boundary patrols (de Waal 1998; Muller and Mitani 2005; Williamson *et al.* 2013). Males might compete with each other when females in the community are in oestrus, but also for rank, in particular when there are changes such as a young male trying to take his place in the hierarchy, an older male loosing influence, males having formed a new coalition, death of a male etc. The communities typically have a clear male hierarchy with the alpha (dominant) male as community leader, though often depending on the support of one or more other males. Most female aggression is related to competition over food or defence of offspring, whereas male aggression tends to result from competition over dominance status, which is about first access to food and females in heat. Female reproduction is limited primarily by environmental resources such as food, whereas male reproduction is limited primarily by access to females (Goodall 1986; Muller 2002; Nishida 1989).

The presence of swollen females (swelling of perineal skin with a max just before ovulation) often leads to formation of large parties of chimpanzees including a large number of adult and adolescent males. In smaller communities dominating males may be able to defend swollen females. In larger communities several high-ranking males may form alliances to protect these females and then tolerate each other mating with them. In some cases, females also manage to slip off into the forest with a preferred consort. Females may copulate with many males early on in the receptive stage, but at the point where likelihood of conception is highest, they have been observed to copulate repeatedly only with high-ranking males (Matsumoto-Oda 1999).

Social interactions are frequently complicated with varying degrees of cooperation, coalition and alliance formation. Juveniles and adolescents tend to associate with their mothers. As they get older, males begin to associate more with adult males, while females often continue to associate with their mothers in early adolescence before transferring to other communities in later adolescence. Females may also use extra group mating as part of their reproductive strategy, without leaving the natal group apart from for mating or transfer between groups more often. (Gagneux *et al.* 1999, Mitani *et al.* 2002, Brent *et al.* 2001)

1.7.2 Behaviour

The complex behavioural repertoire of the species makes this too extensive to describe in any satisfactory way and is outside the realm of these guidelines. The following citation from Caldecott and Miles (2005) clearly embraces this complexity:

It is hard to describe any aspect of chimpanzee behaviour and ecology in isolation from any other. Few of their day –to-day decisions seem to be made taking only one factor into account; individual personality, history and relationships are all crucial influences in the expression of behaviour in different contexts. The options for behaviour are also very wide, since more complex behaviour has been reported for this species than for any other non-human animal. A list of the behavioural patterns displayed by Mahale chimpanzees included over 500 descriptive terms, of which more than 200 were patterns also commonly seen in human and bonobos and about 50 were common to several study populations of chimpanzees but not seen in bonobos.

For detailed information on chimpanzee behaviour, we therefore refer to the ethogram below and relevant literature in the reference list, including Nishida *et al.* (2010), which includes an audio-visual encyclopaedia of chimpanzee behaviour.

Ethogram of species-specific behaviours with a description of each behaviour, Nishida *et al.* 1999 (available as free download):
https://www.jstage.jst.go.jp/article/ase1993/107/2/107_2_141/_pdf/-char/en

SECTION 2. MANAGEMENT IN ZOOS

2.0 Our welfare commitment

Jeroen Stevens, Claudia Rudolf von Rohr

The practical guidelines in the following chapters for chimpanzees 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 chimpanzee 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 Chimpanzee EEP Best Practice Guidelines we follow the vision of this welfare strategy. Chimpanzee 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 chimpanzees with the best possible welfare which includes covering their social needs and provision of mental stimulation and choices (see *Fig. 4*).

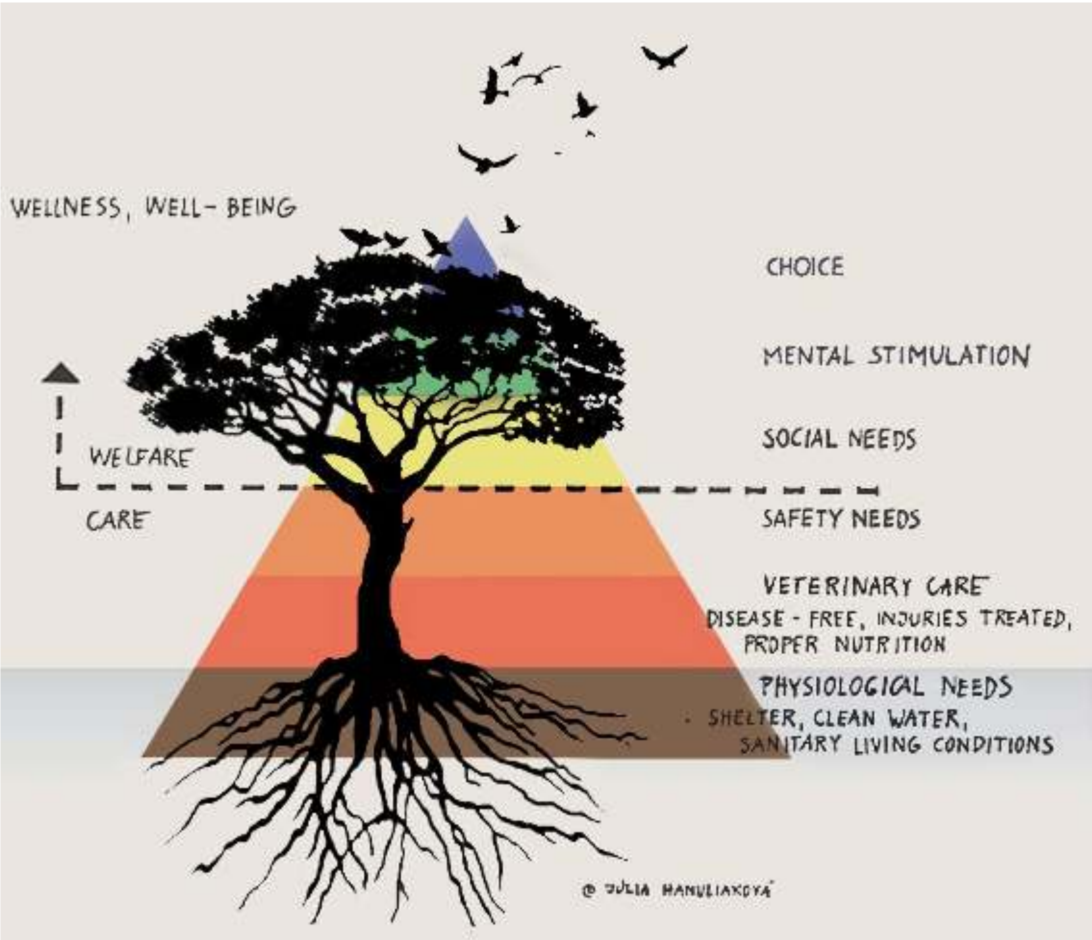


Figure 4: The aspiration of the WAZA Animal Welfare Strategy is to direct animal welfare attention towards the highest categories of Maslow's pyramid of wellness and well-being. The tree's roots represent the critical foundational requirements for survival, including nutrition systems, understood through 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 stress responses have evolved 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 and Beausoleil 2015) is a simple and useful framework for understanding systematic and structured assessments of animal welfare (see *Fig*. 5). 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 (see *Fig.* 6). 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 affects or welfare-compromising negative affects (for more details cf. Mellor *et al.* 2020).

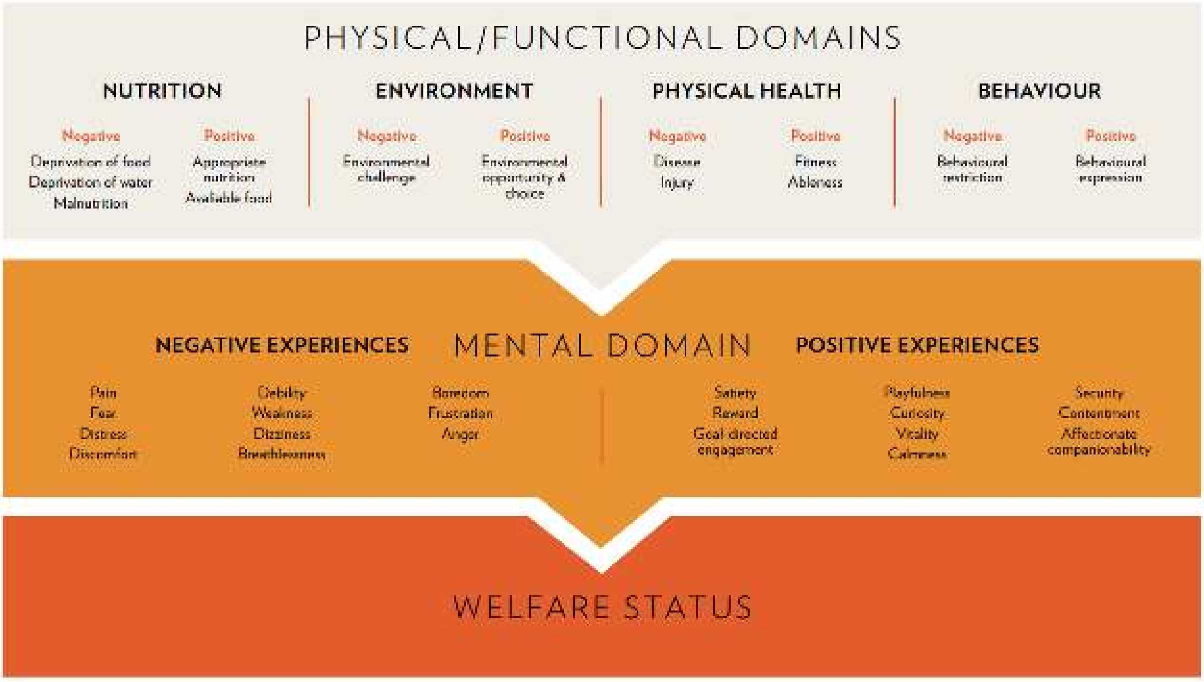


Figure 5: The Five Domains model for understanding animal welfare, divided into physical/functional and mental components, provides examples of how internal and external conditions give rise to negative (aversive) and positive (pleasant) subjective experiences, the integrated effects of which give rise 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 6: 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 chimpanzees is the **24/7 across lifespan** animal welfare concept developed by Brando and 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** (see *Fig. 7*). 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 chimpanzees 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 chimpanzees the composition and dynamic of the social group in relation to a specific individual should also be taken into account. 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).

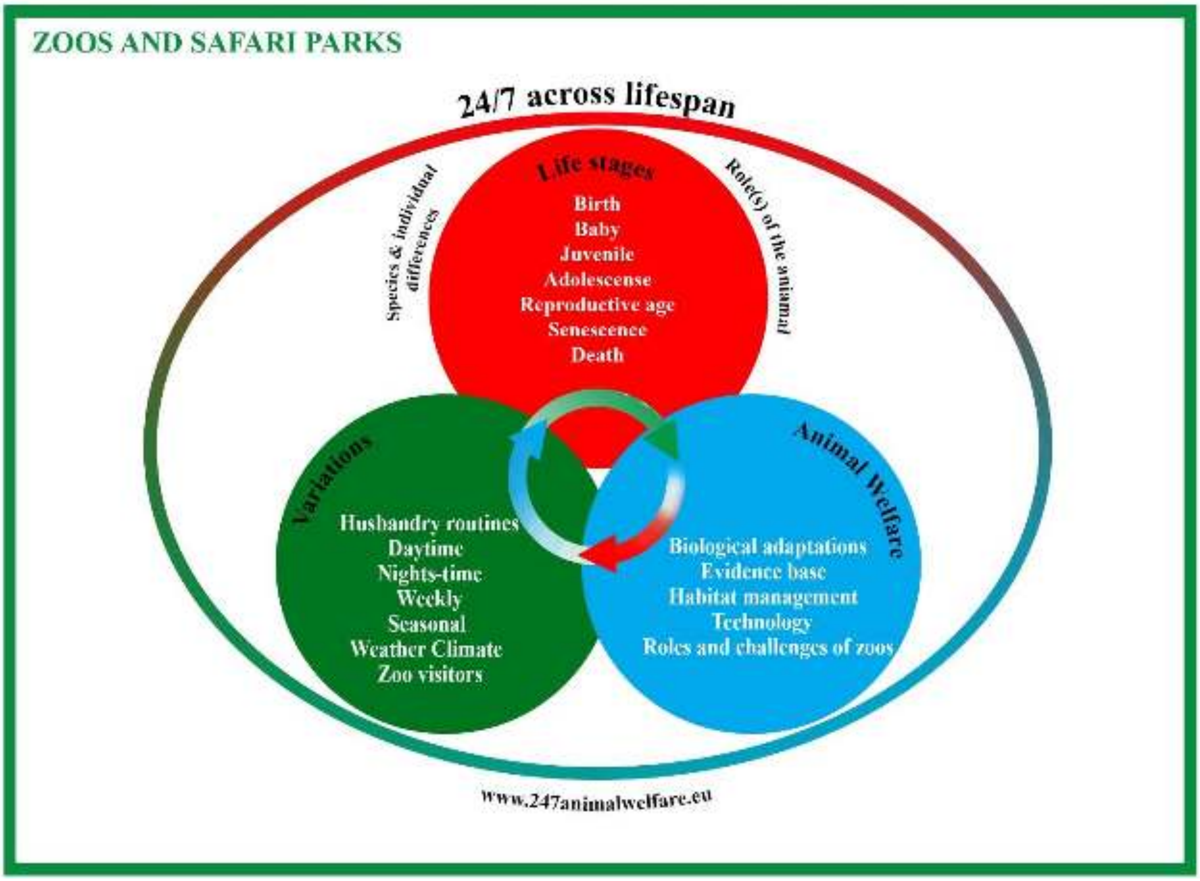


Figure 7: Schematic overview of the 24/7 across lifespan welfare concept. It shows the different life stages and aspects that can influence an individual's life over time (cf Brando and Buchanan-Smith. 2017)

The specifications given in the following chapters are under constant review in order to improve the management of chimpanzees 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. By combining theoretical frameworks and our current practices we will have the best outcome in increasing the welfare for our chimpanzees. Committing to the

WAZA Animal Welfare Strategy means that we proactively provide our chimpanzees 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 in order to reduce stress in difficult management situations - for animals and the staff involved.

2.1 Enclosure (accommodations)

Tom de Jongh

The space in which chimpanzees are being kept should meet the conditions necessary for their individual welfare by providing the physical conditions for a healthy life, by allowing them to express their full behavioural repertoire and by facilitating the natural complex social structure of this species.

An extremely flexible facility, with multiple inside and outside enclosures between which the chimpanzees can freely move around as long as the weather permits, can allow the typical social dynamics, in which the chimpanzees seek each other's company or avoid each other in changing combinations. This system, natural to chimpanzees and other species is called "fission-fusion".

In order to optimize this system, the rooms that are available for the chimpanzees at any time should be connected in such a way that they can circulate between the available rooms.

So, every available room should both have an entrance door and an exit door functional. Ideally, each two interconnected rooms should have two doors between them, preferably as far apart as possible, both horizontally as in height.

In addition to fission-fusion, the flexibility of the facility is also required when new group members are being introduced, which in the long run is unavoidable for all groups.

It also makes it possible to separate chimpanzees from the group if that is unexpectedly necessary, for instance for health reasons, individual training, etc. Since such rooms will also be used for introducing new individuals, we refer to 2.7.1.3 Facility for details of separation rooms. It should be emphasised that in daily management, chimpanzees should stay together day and night in the same room with their group members. Separating individuals during the night in sleeping rooms was common practice in the past but should no longer be done.

2.1.1 Boundary

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 and washability as the walls. Additional strength should allow for the use of hanging furniture and enrichment elements. A wire-mesh ceiling is very suitable for this purpose and in addition provides excellent possibilities for top cage feeding. In particular, in inside enclosures, the use of windows in barrier walls can dramatically increase the size of the visual environment of the chimpanzees and provides a view on neighbouring groups, keepers, public and the surroundings outside. Windows definitely reduce stress and are great enrichment (O'Neil 1989, Prescott 2006).

2.1.1.1 Water moats

Water moats are often used as the preferred barrier for chimpanzee outside enclosures. They provide a natural looking landscape element. However, despite continuous efforts to improve the safety of water moats, drowning of chimpanzees in such moats still occurs.

For new enclosures water moats should be avoided.

For existing enclosures with water moats the next criteria can be used to check if the safety degree is still acceptable. If that is not the case these criteria can possibly be used to decide if the safety can sufficiently be improved or if alternative barriers should be considered:

Under the right conditions, chimpanzees are capable of jumping a horizontal distance of 6m (Coe *et al.* 2001). For that reason, the water moat should be 7m wide or more. (De Jongh, pers. observation) The width of the moat helps to reduce the direct interaction between chimpanzees and visitors, which is one of the factors that can induce a chimpanzee to try and cross the moat and possibly drown. A wide moat also helps to create a gentle slope of the bottom of the moat.

The slope of the bottom of the moat, from above water level on the enclosure side of the moat, to the deepest point of the moat, should be gradual with a slope of max 25cm/m. There should not be a 'step' into the water on the animal side of the moat.

The moat should be at its deepest on the visitor side. This also helps to create a gentle slope of the bottom. A maximum depth of 1.5 m is sufficient as a barrier. A deeper water moat will result in steeper slopes, unless the width will be more in the same ratio.

On the visitor side of the moat, a planted area of a few meters wide increases the distance between visitors and chimpanzees and reduces the interaction.

The bottom of the moat should have a rough surface structure, to avoid that chimpanzees will slide to deeper parts. Remember that algae growing on the bottom will also contribute to a slippery surface.

Ropes or rope nets can be fixed onto the sloping bottom of the moat for chimpanzees to find a hold and help to get out of the moat.

An electric fence can be raised, ca 1 m away from the water on dry land on the enclosure side, so that a chimpanzee that has managed to get into the moat can get back on dry land safely.

In the shape and furniture of the enclosures, 'dead ends' of possible routes for the chimpanzees leading to edge of the moat should be avoided.

Animals that try to drive opponents into the moat should be separated and the coordinators should be contacted for advice.

In addition to the width of the moat a swampy area (vegetated very humid earth of a few meters wide, can reduce the speed of chimpanzees moving toward the edge of the moat and thus reduce the chance of chimpanzees entering the moat accidentally.

It should be noted that these measures only limit the risk of drowning. This risk is not eliminated this way.

2.1.1.2 Glass barriers

Glass walls are often used as barriers in order to provide close-up visitor experiences.

To limit the costs, smaller glass windows built into vertical walls can be used.

Glass can protect the visitors from the dirt and objects, which apes may throw, and it also protects the animals from food items or other materials, that the visitors may throw into the enclosure. Glass can also protect against an exchange of transmittable infections between the animals and visitors.

The big advantage of glass for the visitor experience, the close-up contact with the animals, can be a disadvantage for the chimpanzees. Interactions with the visitors may affect the intra-specific behaviour of some individuals. This effect can be reduced by planting a vegetation belt between the visitors and the glass wall. In some cases, so called one-way glass can be considered.

The thickness of the glass sheets may vary depending on the sheet size. On average 42 mm thickness of tempered, laminated glass seems reliable. When broken, the break generally stays limited to a single layer, and the connecting foil keeps the glass in place.

Glass sheets can be built into the vertical walls or can be combined with electric wires running across the top of the glass panels (only for additional safety, not as a primary barrier!). As for walls a minimum height of 4 meter has proven sufficient for glass panels for chimpanzees.

Because any thickness of glass is potentially breakable, consideration must be given to ease of replacement. Static calculations must always be done by glass specialists, based on the size of the openings and assumed loads. When using glass, special care should also be given to the destructive capacities of chimpanzees, that may use stones, bolts or other hard objects to break or scratch the windows. Multi-layered, hardened glass is more resistant to this behaviour, but daily control of the enclosure and removal of any of such objects should be standard practice. Care should be given to the frame of the window. It should be connected seamless and flush to the surrounding structures (such as a wall), and even fairly small nuts and bolts, extruding from the surface, should be avoided, they can be used to climb the barrier.

2.1.1.3 Dry moats and walls

- **“U-shaped” dry moat**

  Dry moats, made of “U-shaped” parallel walls (see *Fig. 8*.), are not preferred for chimpanzees as these could fall into the moat. Although the risk can be limited by using a proper substrate that may soften the impact, like chopped pine bark or wood chips instead of concrete, this type of moat may still be dangerous. It is well known that sometimes chimpanzees have a need to escape from public view. They may indeed become totally invisible for the public would they climb inside this type of moat.

  When applied despite these disadvantages, a way for the chimpanzees to get out of the moat should be facilitated, just as access for the caretakers.

The moat should then at least be seven meters wide, and the wall on the public side should be smooth and at least 5m high.

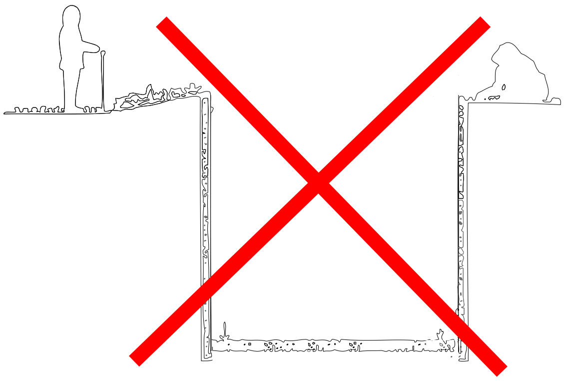


Figure. 8: "U shaped" dry moats are not preferred for chimpanzees

- **"V-shaped" dry moat**

If a "V"-shaped dry moat (see *Fig.* 9.) is used as a barrier for a chimpanzee enclosure, 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 slope at less than 45 degrees and should be able to allow for the natural containment of the soil on the chimpanzees' side.

If the animals can go into the shallow moat, it will give them extra space.

The visual disadvantages of these moats are very similar to those of the "U"-shaped dry moats or to those of other walls, see below.

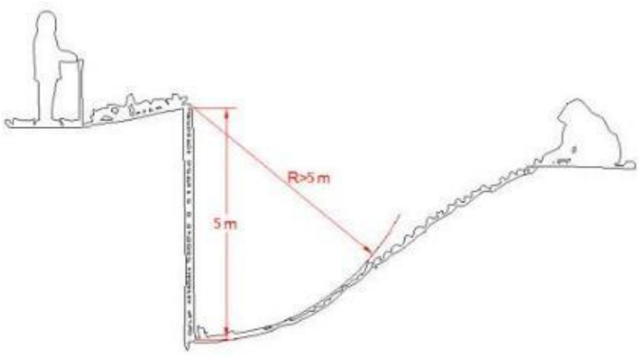


Figure 9. "V"-shaped dry moat

Chester Zoo has an orangutan enclosure with a "V-shaped" dry moat, but with water running over the slope on the enclosure side This example shows how access to the moat can be made less attractive for the inhabitants without any risk on drowning. This could likely also be applied for chimpanzee enclosures (see *Fig. 10*)

Figure 10:

Wet moat of an orangutan enclosure in Chester, with water running over the slope on the enclosure side.

- **Walls**

The goal, obviously, is to create non-climbable walls. The texture must be relatively smooth to prevent foot or finger holds. Doors and windowsills with their hinges or nuts and bolts, which are used for attaching constructive elements to the walls, may be critical points. They should all be kept flush with the surface of the wall itself. Overhangs may be added to prevent climbing. The layout of the walls should avoid perpendicular or acute angles to adjoining walls to prevent "chimneying" out, or they should be capped at these dangerous intersections. Rock climbers have been used in a number of facilities to test the security of containment barriers. However, some great apes are more agile than the finest human rock climbers. In some zoos walls have been decorated to look like natural rocks. With its irregular shapes and surface structures, artificial rockwork deserves careful attention to make sure that it meets the criteria listed above.

Advantages of walls are that they take up very little room and can be less costly than moats or glass walls. 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 6 metres, (including branches of living trees) to prevent leaping out.

Vertical climbing space is important for chimpanzees, and for smaller walled enclosures, it is therefore better to make a wire-mesh roof. The minimum height of the walls should be 4 metres. Chimpanzees are masters in escaping from enclosures using branches which they put in an angle against the wall. They should not have access to branches longer than ca 1 meter that are strong enough to be of any use to them in this way.

Completely enclosed wall space can be very stressful for great apes, as they can often hear noises from behind the walls but cannot see anything that is happening. Therefore, each wall should have several windows. An additional disadvantage of the completely enclosed wall is that wind cannot cool the enclosure when temperatures are very high.

In zoos, we try to raise a respect for animals in visitors, and it has been shown that visitors have less respect for animals if they only see them from above. They can easily throw food or other objects into the enclosure, and they can spit on the animals. All these behaviours are a threat to the health of the animals, but even if visitors behave, it can be threatening and stressful for the chimpanzees to have visitors "above" them.

Finally, there are several cases of careless visitors, mainly children, falling over the edge of walls into enclosures.

2.1.1.4 Fences

Fences are perimeters made out of rows of posts with steel fencing material installed along the line of the posts. For each type of fencing material care should be given to the density of support structures, which very much affect the strength of the barrier. The type of fencing material can vary:

- **Welded mesh**, which has the disadvantage of being less resistant to impacts from heavy blows etc. The welds can break then. When this type of fence is chosen, the quality of the welds deserves careful attention. At each cross of wires, the weld should go around completely, without leaving a gap. Welded mesh is less capable to absorb bounces on it compared to crimped mesh that is less rigid. So, with welded mesh there is more force on the connection to the frame, which may lead to welds connecting the mesh to the frame getting broken (see *Fig. 11*).

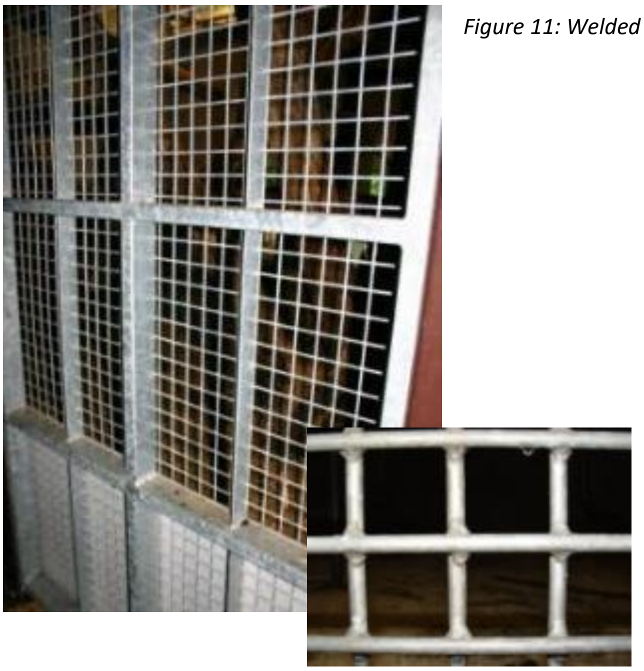


Figure 11: Welded mesh

- **Chain-link mesh** is generally not recommended. It is vulnerable for the destructive skills of chimpanzees. A choice for this material may lead to reduced use of enrichment objects. It may be successfully protected by hotwires on several heights, which has the same disadvantage regarding enrichment items though (see *Fig*. 17.)

- **Steel bars.** With the required heavy framework this type of barrier, given the right dimensions are chosen, can certainly be strong enough for chimpanzees. There is however also a safety issue with this type of barrier. Chimpanzees can put sticks through bars and then swing them up and down, which can be dangerous for keepers. Also, unless a very small distance between the bars is used, chimpanzees can reach more easily through this type of barrier, which causes safety issues both for the caretakers and for neighbouring chimpanzees. With a small distance between the bars however, these will reduce the angle at which sight through the bars is possible. For these reasons this barrier type is not recommended for new fences (see *Fig. 12*).

Figure 12. Steel Bars

- **Steel crimped mesh**, difficult to obtain in a sufficiently heavy quality, but then a very suitable product. Recommended dimensions for this type of mesh: 5 x 40 x 40mm (see *Fig. 13*).

Figure: 13: Steel crimped mesh welded in a steel frame

- **Wave mesh**. Similar to steel crimped mesh. However, the waved strands could be more easily stretched with sufficient force, and the mesh deformed. The space in between the steel profiles can be filled with epoxy to prevent dirt and debris from collecting there (see *Fig. 14*).

Figure: 14. Wave mesh welded between steel profiles (Photo: G. Fernández Hoyo)

- **Cable mesh** from stainless steel cables, an expensive but visually pleasing material. Available in two types, one in which the cables are attached with soft metal rings that are clamped (ferrules), and one in which the cables are inter-woven at the attachment points (see *Figs 15 & 16*).

  Unfortunately, a very few individual great apes from several institutions have so far developed skills to destroy this type of mesh locally and escape. It is important to check the mesh routinely, keep an eye on what chimpanzees are doing with it, and interfere before the individual has improved its skills and passed this on to exhibit mates.

  Note that there are different grades of stainless steel and that this type of mesh is available in different grades, affecting both the price and the resistance to corrosion. The best resistance against corrosion is reached by AISI 316 as material. The strongest cable structure is made of 7x19 strands. For great apes, the mesh width ranges from 5x5cm to 100x100mm and the cable thickness from 2 to 4 mm. The most commonly used type has a mesh width of 6 cm and a cable thickness of 3mm.

Figure: 15: Ferrule type cable mesh.

Figure: 16: Inter-woven cable mesh.

Naturally these fences may be used by the chimpanzees as climbing structures to their advantage, but since such enclosures are open topped, they need to have an un-climbable structure on top for containment. These could be smooth plates from sufficient widths (heights) preferably with an overhang, or even special structures, such as those used in Wareham (see *Fig*. 17).

Hot-wires however should not be used for this purpose. The system is simply not reliable enough to be used as a primary barrier.

Figure: 17: Special overhanging structure as containment on a chain-link mesh fence at Monkey World (Wareham). Note the hotwires to protect the chain-link mesh.

2.1.1.5 Mesh cages

Steel mesh enclosures can be large outdoor cages 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, chimpanzees can use all areas as climbing opportunities. In addition to that, this barrier type itself provides the opportunity to be used as a climbing structure.

Wire ceilings are handy for enrichments like ropes, and roof feeding is also beneficial for animals. Provided that the cage is high enough, this type of enclosure allows for the most efficient use of the available three-dimensional space. Because furnishings such as trees cannot be used as escape methods, this barrier increases the flexibility with which such furnishings can be used.

Fully enclosed exhibits reduce the chances on an escape of the inhabitants.

Stainless steel net structures are expensive, but maintenance costs are very limited (see *Fig. 18*).

Figure:18. Stainless steel net was used for the chimpanzee enclosure at Antwerp Zoo

The support structures of enclosed exhibits provide opportunity to hang climbing facilities, resting platforms or structures for food provision from. In order to service these in the, for chimpanzees necessary, high enclosures, such structures can be raised and lowered using electric winches, or reached by staff trained in working at heights, using harnesses etc. Hook-up points for carabineers can be attached to the climbing structures. These additional loads should be taken into account when calculating the statics for the exhibit construction.

To avoid direct chimpanzee-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. Any type of mesh or fencing should naturally be subject to periodic and reliable maintenance, according to its nature.

2.1.1.6 Electric barriers

Hot-wires should not be used as primary barriers, but could be used to add safety, for instance over the top edge of a wall.

Hot-wires or so called 'hot grass' or 'hot lianas' can be used to protect vegetation within the enclosure. It should be noted that some chimpanzees will develop skills to destruct or to pass the hot wires. This may lead to undesired limitation in the provision of enriching items. Chimpanzees are even able to use relatively 'soft' materials like grass or straw to make tools from.

2.1.1.7 Safety distance

For safety reasons the public should be kept at a distance of 2 m minimum from any mesh around a chimpanzee enclosure, and there should be dense vegetation and a relatively high public fence (min. 1.20 m) between the visitors and the enclosure fence.

2.1.1.8 Service access to the enclosures

Normal access doors should be wide enough to allow for comfortable passage with a wheelbarrow and high enough for any person to pass upright. In practice 1m wide and 2.2m high will be sufficient. Official building regulations may require a greater height.

In order to replace bio floor material, soil, exhibit furniture or technical service equipment, additional service access should be made adequately larger. Recommended width: at least 3m.

All doors into enclosures or the immediate neighbouring part of the boundary should provide good visibility into the enclosure.

Details of the doors and doorframe should be carefully considered regarding strength and its potential to be climbed. If the last cannot be excluded, there should be at least a 3 m, non-climbable boundary above the doors.

The doors should be locked at least at two, preferably three different heights. Locks should be kept out of reach of the chimpanzees.

Access to the service area adjacent to the chimpanzee rooms should be through a door that allows full view on the entire service area, either through a chimpanzee proof glass window in the door, or through a fenced door, in which case a double door is probably required for climatic reasons. The door that allows this view is necessary in to avoid entering the service area when a chimpanzee has escaped from one of the rooms.

2.1.1.9 Barriers between the enclosures

It is very important to protect the chimpanzees not only from visitors, but also from unwanted or stressful neighbouring animal enclosures. Extra outside enclosures with other chimpanzees 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 "peeping" areas, in order to provide an opportunity for the animals to escape the attention 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 6 metres.

Chimpanzees can be quite noisy and sometimes like to throw different things into the neighbouring enclosures during their display. At times their presence may be disturbing or even stressful for other great apes or other species in the neighbourhood. This 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.

2.1.1.10 Animal doors

To provide more flexibility there should be at least two doors between each pair of neighbouring enclosures, including between separation boxes, and these doors have to be positioned as far apart as possible and preferably at different heights. This will reduce the chance that a chimpanzee gets cornered and will facilitate circulation between the enclosures. For the same reason it is very valuable to have two doors between each inside enclosure and the neighbouring outside enclosure(s).

There are different kinds of mechanisms for sliding doors: mechanic, electric, air-hydraulic, oil-hydraulic, etc.

Doors between enclosures should all have an extra security mechanism to prevent chimpanzees from opening the doors themselves. In designing the mechanism for opening the doors between enclosures, it should be kept in mind that chimpanzees 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 doors sliding horizontally and operating manually include this risk. They should preferably move away from the keeper when being opened. Another solution is to use slides with teeth on the handle (see *Figures 19 & 20*). A slightly different version of this system can be seen in *Figure 21 & 22*. In this case the door slides along a strip with teeth that are fixed to the fence construction.

Figures 19 & 20. Sliding door with teeth on the handle as applied for orangutans at Chester Zoo.

Figures 21 & 22. Sliding door that moves along a strip with teeth, fixed to the fence construction.

Cables, which are often used for vertically moving sliding doors, should be well protected and out of reach of the chimpanzees. Nevertheless, the condition of the cables should be checked frequently, similarly with other moving parts and attachments like bolts and nuts. Keepers should not be forced to come within the reach of the chimpanzees in order to handle the doors, for protection against possible aggression.

Bedding can often block a door from being completely closed. The design of the door can be such that the collection of bedding in the door-opening can be limited. The low side of the door opening can be made raised from the ground level, so that bedding does not reach the door (this also allows for a change to deep bedding later).

Being able to block the door at different gaps, has several advantages:

When doors can also be locked while still leaving a small opening free (ca 3 cm) it is possible to approach the door from the other side and carefully remove any material that is blocking total closure of the door. Horizontally sliding doors of the type hanging from wheels in a rail on the topside, can 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 *Figures 23 & 24*).

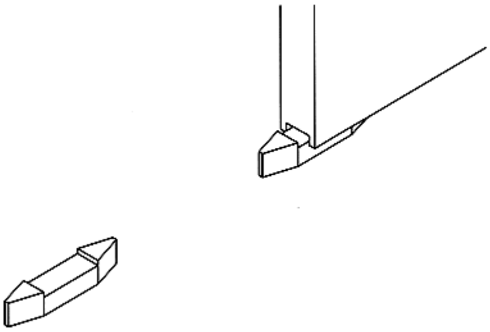


Figure 23. Sliding door with torpedo guides

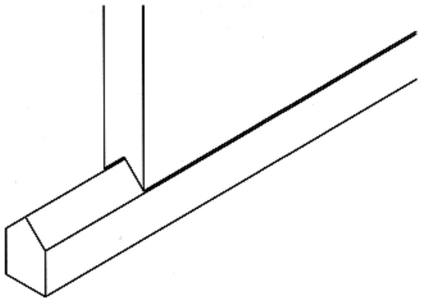


Figure 24. Sliding door on a ridge

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

Keepers must always have a complete view of the full opening of the door when opening or closing it. Hydraulic doors should be such that the movement of the door stops instantly when the keeper lets go of the button. It is also necessary to provide a manual override for hydraulic, pneumatic or electric doors so that these can be used and locked even when the system fails.

The speed of such doors is also critical. They should be fast enough without risking injuries to the chimpanzees.

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 (see also 2.1.6 7 Special features to facilitate introductions) double slide doors are very useful in the solid walls, with one solid slide and one slide with mesh. For additional safety in such situations, one could also consider double mesh doors, at a distance just enough to allow for two chimpanzees from both sides to touch each other's fingertips. For the introduction of chimpanzees, a "Gap" has proven valuable. The sliding door is locked leaving an opening of ca. 12 cm free. Chimpanzees that are being introduced to each other can have some physical contact this way, while still being largely protected. It should be emphasised that this is just one stage of an introduction procedure. (See Appendix IV:" The Gap" from Michael Seres on page 170)

It should also be possible to safely lock the doors in different other positions, to allow selective passage of, for example, all but the adult males or the youngsters only.

The recommended door size is 80 cm wide x 100 cm high.

By also having the possibility to lock the door at a gap of ca 20 cm width, a selective passage is created, allowing young chimpanzees to easily pass the door, while adult chimpanzees are either totally blocked from passing, or need more time to pass, allowing the young animals to get away.

Before the keeper opens the door giving access to the service area adjoining the enclosures, they should have the means to check through a small window or fence that this area is free from escaped chimpanzees. Even better is to have a double door system: staff enters through solid doors first and can then oversee the full-service area from behind mesh doors. In case of an escape these mesh doors allow the chimpanzee to be anaesthetised by means of a blowpipe.

2.1.1.11 Observation facilities

Being close relatives to humans and having complex behaviour, chimpanzees are popular subjects of ethological studies.

While researchers can benefit from observation possibilities, the management of this species can greatly benefit from the presence of observers. It is advised to consider special facilities for observers when designing chimpanzee 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.

Keepers should be able to observe the chimpanzees in any part of the inside areas. This can be achieved by different windows made from glass or mesh or through closed circuit video cameras.

2.1.2 Substrate (landscape, topography and vegetation)

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. For a semi-arboreal primate like a chimpanzee, this complexity should extend into the 3rd dimension and include several elevations.

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. The space in the shadow should be enough for most of the activities of the chimpanzees and should be spread over the entire enclosure so that chimpanzees can avoid each other’s close proximity without being forced to stay in the sun.

2.1.2.1 Substrate and floors

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

Floors: For the purpose of easy cleaning, concrete or epoxy floors should preferably be sloped 2 to 5%. Drains should be placed outside the actual enclosure and can be used as urine collector. 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.

Bio floors: For the recommended use of deep (> 40 centimetres) bedding, the floor and draining 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 infesting the bedding.

For more information and advice on the use of bio floors for chimpanzee enclosures, we refer to the results of the Great Ape TAG bio floor survey (Appendix IV)

The main conclusions from that survey were:

If you plan a bio floor, take care of the following things:

- Doors and sliding doors should be high enough above bio floor level to work properly
- Bringing in and removing bio floor 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 bio floor completely in a timely fashion in case of diseases
- Drainage system (to avoid dust, raise humidity, and control pests, you must water the bio floor!)
- Pest control
- Great Ape TAG veterinary guidelines: carry out the recommended tests before introducing a new animal!
- Detergents used should be biodegradable

Figure: 25. Installing the bio-floor at Twycross Zoo (Photo Twycross Zoo)

Figure: 26:

Turning the bark regularly keeps the bio-floor loose at Walter Zoo

Deep bedding of bark creates a comfortable floor surface for the inhabitants, helps to increase and stabilise 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. Some zoos use earth as substrate in their great ape enclosures. Examples are Leipzig Zoo, Frankfurt Zoo, Osnabrück Zoo and Chester Zoo.

Drainage of bio floors.

Excess humidity should be drained as quickly as possible leaving the bio floor material moist, but not wet. For this purpose, it is important to keep the material loose by turning it regularly (see *Fig. 26*). It also helps to use material with a large particle size.

There is a choice of methods and materials that can be used to improve the transport of excess water to the sink. Much depends on the current situation: Is it a newly planned enclosure of an existing one? Is the sink situated in or outside the enclosure? Is the existing floor sloping in the direction of the sink and if so, with what percentage?

For a new enclosure it is suggested to have the floor sloping at 5% toward the drain. The drain can then be a gutter in the length of the enclosure, if necessary, even several gutters positioned parallel to each other at distances that divide the distance from the highest points to the drain as equal as possible.

It is necessary to filter the water before it enters the drain, in order to avoid the drain to get clogged.

For new enclosures and with the floors designed as indicated with gutters, it is possible to lay drainage hoses in these gutters and connect these directly to the drains. Such hoses are made of perforated plastic, with an outer layer that is traditionally made of coconut fibres (see *Fig. 27*). In newer versions the outer layer is made of Polypropylene fibres, which are also sometimes combined with recycled artificial grass.

Figure: 27. Traditional drainage hose with coconut fibres

A perforated stainless-steel grid should cover the gutter to avoid that the drainage hose can be accessed by the chimpanzees. The grid should be fixed in place in a way that it can be removed to clean the gutter and/or replace the hose when necessary.

For existing enclosures, the filtering is generally done by a thin non-woven material in combination with a thicker layer with a more open character through which the fluid passes to the drains. An example of this is ENKADRAIN®, but there are other types as well. Properties to keep in mind are the degree of it being vulnerable to destruction by the chimpanzees if they reach it through the bio floor material (an additional reason to choose for a relatively thick layer), and the fact that this material may lose its function when pressed together through relatively heavy equipment being used to spread the bio floor material. It seems best for that reason to pump it in through hoses (see *Fig. 25*).

2.1.2.2 Vegetation

Plants and vegetation are very important for dividing the terrain in a natural way, and provide nesting and foraging material for animals (see *Fig. 29*). They are also important for visual barriers and providing seclusion. Chimpanzees can be quite destructive with the vegetation in their exhibit. Nevertheless, several institutions have well-planted enclosures, providing a natural looking environment as well as valuable enrichment. Some bushes, shrubs and trees can be protected by electric fences, fibreglass or metal bark wraps. Trees and large shrubs can also contribute to an essential high proportion of shaded area in the enclosure. Their fruits autumn leaves and deadfall branches can provide additional enrichment. Chimpanzees have also been found not to climb certain palm trees (like fan palms, some of which thrive in subtropical or even mild moderate climates), which can be helpful showing these apes in an impression of their natural, tropical habitat.

Some zoos have also succeeded in maintaining some vegetation in their indoor enclosures (see *Fig. 28*). In the early years of the new facility at Zoo Osnabrück the chimpanzees only had access to the "Wintergarten" during the coldest season. In spring, summer and autumn, the tropical jungle could recover from the destructions caused by the chimpanzees. In the meantime, that has turned out not to be necessary anymore, but such an initial precaution may also be of value for other facilities.

Obviously, successful attempts to create a vegetation in a chimpanzee enclosure are related to the density of the vegetation in relation to the density of the chimpanzee population.

Figure 28. Well planted indoor enclosure at Zoo Osnabrück (Photo Zoo Osnabrück)

Figure 29. Well planted outdoor enclosure at Chester Zoo.

Importantly, poisonous plants need to be removed and controlled on a regular basis. However, some poisonous plants, such as laurel (*Prunus lauroceratus*) are not eaten by chimpanzees, probably due to their bad taste, which makes them very suitable for vegetation in the enclosure. For the further details about the suitable vegetation please refer to the Zoo Plant Wiki, developed by Sergio Pacinotti for the EAZA Zoo Horticultural Group, which can be found on the EAZA website (http://www.zooplants.net/index.php/Main_Page).

2.1.3 Furnishings and maintenance (incl. climbing structures)

2.1.3.1 Furnishing

Physical complexity includes not only the well-designed topography and the landscape, but good furnishing as well. In a good, naturalistic enclosure the 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 browse, but also as very useful play objects and potential tools. If chimpanzees can potentially use branches also for undesired destructive purposes or escapes, access should probably be limited to thin twigs and with limited length or partly broken in various places

Furniture has to be designed to fulfil the basic behavioural requirements of different sex and age groups. 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 chimpanzees or from visitors. Good furniture should serve this requirement as well.

Variety in the furnishings and a rich range of items offering behavioural stimuli increases the possibility for the chimpanzees to develop and display their full behavioural repertoire. Spatial variety helps to give different areas and spots different functions. Favourite areas for sleeping, playing, feeding etc. can be provided. Sightscreens, selective barriers etc. help to reduce social tension by providing opportunities for quick flight or hiding. The variety of ideas for behavioural stimuli is enormous. Many of them can only be applied when integrated into the architecture and engineering system. The opportunity to integrate such elements in the design of a new or renovated enclosure should not be missed. At least a large number of attachment points, such as eyehooks, should be provided. These can be placed on walls, floors, ceilings but also on the furniture.

Valuable behavioural stimulation can be achieved by making regular changes to the furniture and exchanging stimulating items by novelties from time to time. A large number of available attachment points on various points help to make stimulation more flexible.

It is important to spend great care on the attachments and connections of the furniture in the enclosures.

Twycross Zoo and the University of Birmingham developed the Enclosure Design Tool.

This online tool allows caretakers to monitor the behaviour of their zoo chimpanzees. The Tool then compares the results with the behaviour of chimpanzees in the wild, and advices on enclosure design that will allow chimpanzees to behave in a more natural way.

https://www.birmingham.ac.uk/schools/biosciences/research/showcase/enclosure-design-tool/index.aspx

2.1.3.2 Safety distance

In open-top enclosures with walls, glass panels or fences as boundaries, any furniture, climbing structures, branches from live trees etc. in the enclosure should not have a smaller horizontal distance to the boundary than 6 m.

2.1.3.3 Climbing structures

Chimpanzees are semi-arboreal animals. Therefore, they need trees or artificial climbing structures. The diameters of the climbing structures should vary and fit to all age-groups. Height and complexity of the climbing structures, composed of both vertical and horizontal elements, is very important. The higher, the more complex the structure can be. Chimpanzees use various types of locomotion in the canopy and the climbing structure should facilitate this sufficiently. They often walk quadrupedally over heavy branches, but also sometimes brachiate, hanging from branches thin enough to grasp with their hands. Climbing structures can be constructed using wooden poles, tree stems, ropes, nets and platforms.

Figures 30, 31 and 32. Examples of good climbing structures at Twycross Zoo (Photo Twycross Zoo), *Edinburgh Zoo and Espace Zoologique St. Martin la Plaine (Photo Espace Zoologique St. Martin la Plaine)*

Great ape enclosures are not playgrounds for apes, and climbing structures are not meant for them to demonstrate or practice their gymnastic skills. Great apes in nature inhabit a complex and very three-dimensional habitat in which they find food, sleep, meet conspecifics avoid predators etc. They travel mainly on the ground, but also through the canopy. In our zoos they should be able to find their ways in a similar way through a three-dimensional climbing structure that includes routes that can lead them to all the places in the enclosure that meet their requirements (see *Figs 30*, *31* and *32*).

Chimpanzees also need privacy, and both on the ground level and in the furniture sightscreens and secluded nesting places in various heights can provide this.

2.1.3.4 Flexible climbing material

For semi-arboreal primates like chimpanzees, flexible climbing material is of very great value. Traditionally, ropes are being used for that purpose. It should well be realised however that ropes can be dangerous for great apes. The ropes can be untwisted, and then the apes can put their heads through and hang themselves accidentally. Frayed ropes can also be eaten, and in particular some synthetic rope types (incl. nylon) can then curl up and block the intestines. Some types of polypropylene rope look very similar to natural hemp ropes. They have good UV resistance, so can be used outdoors as well. For those reasons it is very important to select, prepare and hang the ropes with great care, and make sure that, through good maintenance, the presence of frayed ropes is being avoided. Braided ropes are much harder to untwist than twisted ropes. Some types of rope are more tightly twisted than others.

The ends of the ropes deserve extra care, since these are the places were fraying starts. Attaching both ends of the ropes makes it harder to untwist the rope etc.

There are also good alternatives for ropes, such as old-fashioned canvas fire hoses (some newer types contain nylon fibres, that have the same risk as nylon ropes (see above)) and special webbing as traditionally used for safety equipment (see *Figs 33 & 34)*

The webbing material has proved very robust, and although some pieces may have to be replaced now and then, the majority will stay intact for many years.

It is very easy to install, simply by using a double knot and fixing a steel 'jubilee clip' at the end to secure. When the webbing is cut you just need to seal the end by melting the edge quickly with a flame. This stops any fraying.

Figures 33 & 34: Webbing material, as used for orangutans at Chester Zoo and for chimpanzees at Twycross is also very suitable as a flexible climbing material (Photos Chester Zoo and Twycross Zoo)

2.1.3.5 Nesting places

A variety of constructions from other materials have been successfully used to provide nesting places. These can include wooden platforms, steel frames (see *Fig. 35*), hammocks made out of fire hoses, webbing or a dense rope net.

Figure 35: Example of a nesting place at Edinburgh Zoo

Inter-individual distances between nesting places and choice of nesting places are important for all great apes. There should be more nesting places than individuals in the enclosure and some of the nesting places should be large enough for co-nesting (Weiche & Anderson 2007).

Naturally, sufficient suitable nesting material for the chimpanzees to build their nests in these places is also required.

2.1.3.6 Shelter and hiding places

Shelters and hiding places are essential for shade and protection from heavy rain, severe weather or blazing sun. Hiding places will also provide privacy from other individuals and from the public. Hiding places should be set up preferably so that they cannot be monopolised by high-ranking animals. It is best to provide shelters on different heights.

2.1.3.7 Water source

Clear water must always be provided. This can be done by drinking nipples 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.

Waterfalls or shallow pools can enrich the behaviour and increase the daily activity of chimpanzees. The introduction of water in streams and pools adds a tremendous dimension to the daily environmental experience for both chimpanzees and visitors. Depths of less than 50 cm can be considered safe for chimpanzees.

2.1.4 Environment (indoors and the outdoors)

2.1.4.1 Lighting

Indoor enclosures need to have a high amount of natural light. This can come from well protected skylights and/or windows (think of the risks of broken glass falling into the enclosures), but also through completely clear roofs, from either glass, layered acrylic, polycarbonate sheets or ETFE building cladding systems. These materials also allow the infrared spectrum of the sunlight to pass through. It may be necessary to install a shading cloth system to protect the enclosure from overheating.

Artificial light is needed to increase the day length in our darker seasons, compensate the reduced light levels of gloomy days and provide sufficient light for good working conditions for the staff.

In their natural habitat chimpanzees always encounter spatial variation in light levels.

A choice between different light levels (average ca 300 lux or more, variety between 80 (shaded places) and 500 lux at ground level) might be beneficial to them. If necessary, an additional light system could be provided. This should create good working light conditions for servicing the enclosures, even in areas normally kept shaded for the chimpanzees. The colour of the lights has a psychological effect on the chimpanzees. A colour temperature of 5000-6000 K is most similar to the colour temperature of sunlight. For fluorescent lights nr. 83 is recommended.

For colour representation a Ra of 80 or more (this is not the colour of the light, but a measure for the reliability of the way colours are being seen by humans).

Light intensity should come on gradually and also be switched off gradually. The presence of low intensity lighting (max. 5 lux on the floor) during the night can be very helpful. Next to allowing some vision for the chimpanzees during this period, it also allows a visual check on the facility and its inhabitants without the need to disturb these by switching on the main lights.

With a combination of day-light and artificial lighting, the light period of the day should be at least 10 hrs throughout the year (daylight length has generally hormonal effects affecting lactation, cycle etc.)

2.1.4.1.1 UV Light

When climatic conditions allow for very limited access to the outside area, insufficient exposure to UV light may lead to vitamin D3 deficiencies (Junge *et al.* 2000, Videan 2007). During the colder season (October – May) the amount of UV light in Europe is insufficient overall regardless of the duration that the chimpanzees will be exposed to sunlight. This can be overcome by feeding vitamin supplements. (see chapter 2.8.6.4.9 Vitamin D deficiency).

Exposure to UV light is very important for good health but supplying artificial UV light has many disadvantages. It is extremely difficult to give the proper dose, and while overexposure has serious health risks, underexposures will fail to have the desired effect.

Access to the outdoor enclosure for as long as the weather permits, if only for a short period per day is very important for that reason. Even transparent roof light materials that have relatively good UV-B passage can lead to under-exposure of these wavelengths. Dirt, condensation, reflection, aging of the material etc. will affect the effective passage of this valuable type of radiation in a negative way. The actual wavelengths of UV light that are of value for Vit. D3 are generally on the edge of the spectrum that passes through these materials.

All light fixtures have to be well protected, to avoid broken lights falling to the enclosure floor.

2.1.4.2 Temperature

2.1.4.2.1 Outside climatic conditions

While in the EEP region as a whole a combination of indoor and outdoor enclosures is required for the keeping of chimpanzees, it should be remembered that the climatic conditions within the region differ considerably. As a result, some of the typical functions of inside accommodations can be provided outside when the chimpanzees are kept in a warmer climate. There, one can also expect the chimpanzees to spend more time in the outdoor enclosures. The conditions in and dimensions of outside accommodations in these warmer climates can be expected to reflect this emphasis on the outdoor, and so should the complexity of the landscape and climbing structures. Nevertheless, indoor accommodations should, even in southern Europe, be suitable to provide a complete living space for the colder part of the year.

It is essential to realize that for chimpanzees the complexity of the facility is an important element. When for climatic reasons less of this complexity is offered indoors, this can be compensated outdoors, or the other way around, when less complexity can be offered outside, this should be compensated indoors.

All species of great apes are inhabitants of tropical forests where they usually live in the shade of the dense canopy. Shade is a very important element in the exhibits and should dominate in these while sufficient direct sunlight should be available also. Free choice between shaded and sun exposed areas is important regardless the social situation. So, shade should not be limited to a single part of the enclosure. It is obvious that shade is even more important in those parts of the EAZA region with high summer temperatures.

On the other hand, in the more northern parts of the EEP region it is to be expected that the chimpanzees will spend most of their time inside. The size and conditions of the inside accommodations in these regions can be expected to far exceed those traditionally seen in milder climates. Sun exposure of the outside enclosure is more important in those facilities, but shade however is still required.

2.1.4.2.2 Indoor climatic conditions

Providing choice of individual preferred temperature, there should be a gradation of temperatures throughout the enclosure. Indoor temperatures should not normally exceed 30º C throughout the whole enclosure. During the colder season heating should provide for an average temperature of 18-20º C.

When the outside conditions may just allow free choice access to the outdoor enclosure (minimal 10º C when rainy and windy, down to below zero degrees when sunny and without wind), the temperature indoors can be kept a few degrees lower than normal to reduce the difference in temperature between the inside and the outside. By providing several doors between each indoor enclosure and the neighbouring outdoor enclosure(s) chimpanzees are never forced to stay outside by others nor to be involuntary exposed to extreme temperatures.

If the chimpanzees are exhibited in an outdoor enclosure with no access to an indoor one, one has to evaluate the climatological conditions before allowing the chimpanzees to go outside. Rainy, windy, cloudy days and temperatures under 10ºC, are conditions under which chimpanzees should not remain outside for a long period of time. The presence of particularly sensitive individuals such as very old chimpanzees or new-borns should also be reason to be a bit more careful letting them out in cold weather.

2.1.4.2.3 Ventilation

Sufficient ventilation of the indoor facility is important to keep the summer temperature within limits, remove excess gasses like ammonia, carbon hydroxide, carbon monoxide, and reduce virus infections. (For guidance: For living rooms in houses a ventilation degree of > 0,7 litre/s per m^2 floor surface is required).

Draught, noise and removal of badly needed humidity are negative consequences of ventilation, so well-balanced ventilation is important, lost humidity is being replenished and the airflow diffused in order to limit draught to a minimum.

2.1.4.2.4 Humidity

Relative humidity with the recommended temperatures during the colder season can range between 50% and 80%. Deep litter bedding (bio floor) of fir bark helps to increase and stabilise the humidity. Sprinkler systems can be used to keep the deep litter moist (not wet) and raise the air humidity.

2.1.4.2.5 Sound

Chimpanzees are noisy. They are very vocal and as a group can produce a high sound level.

Particularly the males also use loud mechanical sounds as part of their displays. By rhythmically banging steel doors etc. they do not only impress their competition with the noise produced, but work on the nerves of the other chimpanzees, their caretakers, and in many cases the other species in their immediate surroundings.

There are several ways to reduce the noise:

Sliding doors that are constructed from two layers of steel plate with isolation material in between can absorb a major part of the hits on the door and reduce the noise.

Using rubber rings in between the frame of the sliding door and the construction of the fence that it is attached to, also reduces the noise by preventing that the vibration is passed on to the fence.

Welding steel ribs to the sheet metal of the sliding doors makes banging the doors very uncomfortable for the chimpanzees. They will avoid that (see *Figures 36* & *37)*. A distance between the ribs of ca 5-6 cm works best, since the chimpanzees cannot kick the door in between the ribs then. Since chimpanzees have a need to display with noise, they should have alternative “drums” that should be made to limit the noise to an acceptable level.

It is also advisable to pay attention to optimal use of sound absorbing materials and construction. In particular, the walls and ceilings that are out of reach for the chimpanzees provide good opportunities for the application of such materials.

Figures 36 & 37:
Sliding doors with steel ribs welded on the sheet metal of the doors to prevent the chimpanzees from rattling, kicking or banging on the metal surfaces. (Photos Michael Seres)

2.1.5 Dimensions

2.1.5.1. Area

The intention of Best Practice Guidelines is not to set minimum standards, but instead to stimulate holders to provide the best possible facilities.

For that reason, we provide dimensions of selected facilities that can be regarded as examples.

Outdoor exhibits:

Zoo	Area	Current group size
Edinburgh	1,832m²	18
Arnhem	ca 4000 m²	15
Basel	550 m²	14
Twycross	2641 m²	18
Ostrava	1210 m²	8
Kharkov (in construction)	2053 m²	6
Antwerp	900 m²	8
Leipzig A	3600 m²	17
Leipzig B	1275 m²	8

Indoor exhibits:

Zoo	Area	Current group size*
Edinburgh	175m²	18
Arnhem	300 m²	15
Basel	200 m²	14
Twycross	352 m²	18
Ostrava	233 m²	8
Kharkov (in construction)	235 m²	6
Antwerp	245 m²	8
Leipzig A	417 m²	17
Leipzig B	177 m²	8

It should be kept in mind that the surface area of the enclosures is not a complete measure of the available space and its living qualities for the chimpanzees (see 2.1.5.2).

Some zoos have multiple indoor and/or outdoor enclosures. In some of these cases all enclosures are available for a single group and then improve the flexibility of the enclosures and the possibilities for the chimpanzees to separate themselves from certain other group members (fission-fusion). This is in particular valuable for zoos that do not have the space for a large exhibit in which by benefitting from a good spatial structure including sufficient visual barriers, chimpanzees can find the required privacy.

Other zoos have multiple enclosures that house separate groups. In some cases, a very small additional outdoor enclosure provides the opportunity for a temporarily separated animal to go outside.

The type of barrier also plays a role. In completely enclosed exhibits, the full volume of the enclosure can be made available for climbing structures. In open top enclosures, climbing structures should be kept at more than the maximum jumping distance from the perimeter, thus limiting the usable volume (see 2.1.3.2).

2.1.5.2 Height

Wild chimpanzees spend much of their active time and nearly all of their resting time in the forest canopy. To mimic the three-dimensional complexity of the canopy and facilitate the various types of locomotion that chimpanzees use to move about in the canopy, the height of enclosures is an important and often underestimated element. Where the available area is

* Not necessarily the full capacity of these enclosures

limited, a relatively high enclosure can partly compensate the limited space in particular when the space is filled with climbing structures that make the full volume accessible for the chimpanzees (see *Fig. 38*).

Figure 38:
Example of an inside enclosure with a good height in Kazan Zoo

2.1.6 Special features to facilitate introductions

For information on these features, see 2.7.1.3 Facility

2.1.7 Facility for crate training

The anaesthesia of chimpanzees in preparation of a transfer, including the unavoidable risks and discomfort for the individual can be avoided by training the individual to voluntarily enter into its transport crate and to feel comfortable with it. The process can take quite some time, so, if possible, it is advisable to plan where the crate can be placed in front of a sliding door during the training period, without interfering with the daily management of the chimpanzees. Special attachment features, such as eye hooks to the wall around the sliding door can make it easier to secure the crate in place.

2.2 Feeding

Louise Cox

In order to effectively feed chimpanzees in captivity, it is important to be aware of their wild diet composition, natural behavioural repertoire and diseases that may affect captive individuals. Captive chimpanzees can develop health problems if they are not appropriately fed. For example, Laurence *et al.* (2017) found that problems with the digestive system caused 14% of deaths in chimpanzees housed a research facility in Texas. Similarly, heart disease is a common cause of death, not only for chimpanzees (Laurence *et al.* 2017; Varki *et al.* 2008) but other great apes such as gorillas (Strong *et al.*, 2017). Obesity is also a concern for captive chimpanzees (Videan, Fritz and Murphy 2007) and regurgitation and reingestion behaviours have been documented (Mulder *et al.* 2016). Providing an appropriate diet could help to prevent these issues and should be developed from wild diets and current research.

2.2.1 Captive dietary research

There is a surprising lack of literature for captive chimpanzee diets and their nutritional requirements, similar to many other primate species (Crissey and Pribyl 1997). Cabana, Jasmi and Maguire (2017) conducted a diet change on a group of chimpanzees where water soluble carbohydrates were reduced from 61.9% to 47.5% of the diet over a period of weeks. As water soluble carbohydrates decrease, the fibre (NDF) fraction increased, from 14.4% to 22.8%. This diet changes significantly affected chimpanzee behaviour; inactive and abnormal behaviours decreased whilst travelling, foraging, investigative and social affiliative behaviours increased (Cabana, Jasmi and Maguire 2017). Furthermore, blood glucose levels were monitored and were highest pre-diet change, suggesting a decrease in water-soluble carbohydrates is beneficial to preventing prediabetes (Cabana, Jasmi and Maguire 2017). A study by Milton and Demment (1989) on captive chimpanzees at Yerkes Regional Primate Research Centre tested chimpanzee ability to digest meat. The authors suggested chimpanzee facial structure is not designed to chew meat; with a long rectangular palate, and observations suggested chimps used their teeth and tongue to roll meat and crush it, rather than chew it (Milton and Demment 1989). However, faecal samples did not reveal any meat matter, signifying that chimpanzees are effectively able to digest the meat given in this study (Milton and Demment 1989). Another study on captive chimpanzees investigated the effect of diet on faecal bacteria (Petrželková *et al.* 2012). Feeding a low fibre diet (14% NDF) had a larger increase on the number of ciliates (bacteria) in chimpanzee faeces compared with feeding a higher fibre diet (Petrželková *et al.* 2012). However, the lower fibre diet had a higher starch content, which may have also contributed to the increase in bacteria.

2.2.2 Dietary related health concerns

2.2.2.1 Regurgitation and reingestion.

Regurgitation and reingestion (R/R) is a relatively common abnormal behaviour displayed by captive apes. This behaviour involves the regurgitation of food matter into the mouth which is sometimes expelled to nearby surfaces, and then licked and eaten again by the individual

(Baker and Easley 1996). R/R was studied by Mulder *et al.* (2016) in seven chimpanzees. Increasing dietary fibre significantly decreased R/R, however the results were only temporary perhaps suggesting dietary variation is more influential at reducing R/R than a high fibre diet alone (Mulder *et al.* 2016). The diet increased from 2.2% to 9.3% fibre, below NRC (2003) recommendations, which may have resulted in a lack of long-term effect. Baker and Easley (1996) reported 11/13 chimpanzees at Yerkes Regional Primate Research Centre performed R/R, and this behaviour constituted 50% of all abnormal behaviours. R/R was most frequently seen 4-5 hours after feeding, and it was suggested that the long time between the two daily feeds (due to husbandry routines) increased motivation for chimpanzees to perform R/R due to feeling hunger during this time (Baker and Easley 1996). Captive husbandry routines should therefore consider the effect of stress and long periods without food which is unlike wild chimpanzees feeding routines (Baker and Easley 1996). However, Struck *et al.* (2007) found R/R behaviour was most frequently seen immediately after feeding. An investigation into the impact of different feeding regimes on a 15-year-old male chimpanzee who had been displaying R/R behaviours over seven years was conducted by Struck *et al.* (2007). Previous dietary changes (e.g., removing fruit and replacing with high fibre vegetables) was unsuccessful in reducing R/R in this individual. Two treatments conditions were tested; providing browse and giving an additional feed (containing cereal, sunflower seeds, peanuts, popcorn and chicken) (Struck *et al.* 2007). Providing browse significantly increased the time spent feeding, reduced the time spent performing R/R behaviour (from 2.3% to 0.3%) and reduced the number of times R/R was performed from 2.7 bouts per hour to 0.5 (Struck *et al.* 2007). The authors hypothesized that including browse creates a diet more representative of that of wild chimpanzees, by increasing dietary fibre. This would increase the satiation of the diet, thus reducing the desire to regurgitate and reingest (Struck *et al.* 2007). The increase in feeding time was due to the manipulation of the branches, leaves and stems, again mimicking the behaviour of wild chimpanzees (Struck *et al.* 2007). Therefore, providing browse is not only beneficial to a chimpanzee's nutritional needs, but could also reduce unwanted abnormal behaviours such as R/R. In contrast, providing an extra feed increased the time spent performing R/R (2.3%-4.2%) and increased the frequency of R/R from 2.7 to 4.4 bouts per hour. This feed was consumed more quickly than browse – perhaps leading to less satiation from the diet, increasing motivation to perform R/R (Struck *et al.* 2007). Providing high fibre diets, providing browse and limiting the time between feeds could all help to reduce the occurrence of R/R behaviours in captive chimpanzees.

2.2.2.2 Obesity

It is important to monitor body weights of captive primates (Schwitzer, Polowinsky and Solman 2009), and Body Mass Index (BMI) is one way of measuring the health. Captive male chimpanzees have been shown to have a higher BMI than females (Videan, Fritz and Murphy 2007). Abdominal skinfold measurements are also a good indicator of obesity in females, but not in males although this could be due to males having a higher proportion of muscle mass, rather than fat (Videan, Fritz and Murphy 2007). Measuring chimpanzee BMI is not practical in many instances as measurements can only be taken under anaesthetic, however body condition scoring is non-invasive, and should be regularly undertaken (see also section 2.2.4.1).

2.2.2.3 Blood pressure

High blood pressure (hypertension) in humans can indicate risk of cardiovascular disease (Kazzam *et al.* 2005), and cardiovascular problems have been noted as a cause of death in captive chimpanzees. Ely *et al.* (2011) developed blood pressure guidelines for chimpanzees, based on the blood pressure of 231 healthy adult chimpanzees (*Table* 4). The median systolic pressure for healthy chimpanzees was 126, and the median diastolic was 63 (Ely *et al.* 2011). Additionally, it was found that chimpanzees with a systolic pressure >90th percentile had a significantly increased risk of death (Ely *et al.* 2011). In comparison with wild chimpanzees in Gabon, older captive chimpanzees are at higher risk of increased diastolic blood pressure (Ely, Zavaskis and Lammey 2013). Additionally, obese female chimpanzees are more likely to have increased systolic blood pressure, but systolic blood pressure in males is unaffected by weight (Ely, Zavaskis and Lammey 2013). However, the wild Gabonese chimpanzees were younger, as well as having a diet naturally lower in salt, which may be the reason for lower blood pressure (Ely, Zavaskis and Lammey 2013).

Table 4: Healthy adult (over 10 years) chimpanzee Blood Pressure Guidelines (Ely et al., 2011).

	Systolic	Diastolic
Healthy (<90th percentile)	<147	<84
Pre-hypertensive (90-94th percentile)	148-153	85-88
Hypertensive (> or = 95th percentile)	>154	>89

2.2.2.4 Diabetes

Type two diabetes has been documented in at least 20 species of non-human primate, including chimpanzees (Hansen 2004). In old world monkeys, type 2 diabeties is most commonly seen in obese and older individuals (Wagner *et al.* 2006), and the combination of stress, obesity and living longer than wild counterparts is a potential risk factor for captive primates developing 2 diabeties (Reamer *et al.* 2014). A study of diabetes in 81 healthy chimpanzees reported the median fasting glucose level was 88mg/dL (McTighe *et al.* 2011) and *Table 5* shows the reference ranges described. Cabana, Jasmi and Maguire (2018) found one chimpanzee may have been at risk of pre-diabetes with a blood glucose level of 108mg/dl^{-1}, and one chimpanzee in the healthy range at 104mg/dl^{-1}. However, after a diet change to reduce water soluble carbohydrates and increase fibre, both chimpanzees blood glucose levels reduced to 98mg/dl^{-1} and 94mg/dl^{-1} respectively (Cabana, Jasmi and Maguire 2018). It is therefore important to provide high fibre diets to help prevent pre-diabetes in captive chimpanzees. Reamer *et al.* (2014) evaluated the success of training 123 chimpanzees to provide blood samples via a prick on a finger for blood glucose testing. In the first training session, 29% of chimpanzees completed all the behaviours asked, and 64% partially completed the training session (Reamer *et al.* 2014). Individuals with prior training in voluntary anaethetic injection training were more likely to participate (Reamer *et al.* 2014), suggesting that training may provide easier management of a diabetic individual.

Table 5: Diabetic indicators in healthy chimpanzees (McTighe et al. 2011).

	Fasting blood glucose (mg/dL)	HbA1c[1] (%)
Healthy (<85th percentile)	< or =105	< or = 5
Pre-diabetic (86-94th percentiles)	106-119	5.1-5.2
Potentially diabetic (>95th percentile)	>or= 120	>or= 5.3

2.2.3 Captive nutrition

2.2.3.1 Nutrient requirements

Exact nutrient requirements will vary based on animal age, growth rates and stage of reproduction. For example, protein requirements will decrease with age for many primates (Oftedal and Allen 1996). *Table 6* shows current nutrient recommendations for primates and chimpanzees specifically, from the National Research Council (2003), and a wild comparison. There is a general agreement among zoo nutritionists and researchers, that ADF (Acid Detergent Fiber) and NDF (Neutral Detergent Fiber) should be towards the higher end of these recommendations, if not higher. Wild blue monkeys, mangabeys and red-tailed monkeys also have high NDF in the diet (minimum 31.3%) (Wrangham, Conklin-Brittain and Hunt 1998) suggesting wild primates consume more fibre than recommendations suggest. Additionally, these recommendations are from 2003, and since then the importance of fibre has become increasingly recognised.

[1] *HbA1c is a test that determines the amount of blood sugar (glucose) attached to haemoglobin. A high percentage may be a sign of diabetes*

Table 6: Nutrient recommendations on a dry matter basis for adult primates, post weaning, and chimpanzees specifically (National Research Council, 2003).

Nutrient	Wild diet analysis (Dry Matter Basis) (Conklin-Brittain, Wrangham and Hunt, 1998).	NRC primate adult, post weaning recommended concentration	NRC chimpanzee specific recommendation
Lipids (%)	Max. 8.5		
Crude protein (%)	9.5	15-22	14
Essential n-3 fatty acids (%)		0.5	0.5
Essential n-6 fatty acids (%)		2	2
NDF (%)	33.6	10-30	20
ADF (%)	19.6	5-15	10
Calcium (%)		0.8	
Total phosphorus (%)		0.6	
Magnesium (%)		0.08	
Potassium (%)		0.4	
Sodium (%)		0.2	
Chlorine (%)		0.2	
Iron (mg/kg)		100	
Copper (mg/kg)		20	
Manganese (mg/kg)		20	
Zinc (mg/kg)		100	
Iodine (mg/kg)		0.35	
Selenium (mg/kg)		0.3	
Trivalent chromium (mg/kg)		0.2	
Vitamin A (IU/kg)		8000	
Vitamin D3 (IU/kg)		2500	
Vitamin E (mg/kg)		100	

Vitamin K (mg/kg)		0.5	
Thiamine (mg/kg)		3	
Riboflavin (mg/kg)		4	
Pantothenic acid (mg/kg)		12	
Available niacin (mg/kg)		25	
Vitamin B6 (mg/kg)		4	
Biotin (mg/kg)		0.2	
Folacin (mg/kg)		4	
Vitamin B12 (mg/kg)		0.03	
Vitamin C (mg/kg)		200	
Choline (mg/kg)		750	

2.2.3.2 Energy Requirements

A formula for great ape energy requirements has been proposed as basal metabolic rate (where BMR (Basic Metabolic Rate) equals 50.4 x (Body Weight)$^{0.774}$) times by FMR (Field Metabolic Rate) factor (1.25) (Plowman 2016). For a 60kg chimpanzee this would provide an estimated energy requirement of 1498kcal a day for basic maintenance. Energy requirements will vary depending on activity levels, during different life stages and will increase during pregnancy and lactation.

2.2.3.3 Composition of diet

Captive diets should aim to replicate the nutritional composition of a wild diet, rather than individual food items (Schwitzer, Polowinsky and Solman 2009). Whilst wild chimpanzees consume mostly fruit, it is widely accepted that wild fruit varies nutritionally with cultivated fruit that is often fed to captive animals (Cabana, Jasmi and Maguire 2018), with wild fruits being lower in sugars and higher in fibre (Ban *et al.* 2016; Crissey and Pribyl 1997; Oftedal and Allen 1996). Equally, the diversity of food items an animal eats in the wild does not necessarily reflect the amount of food items an animal requires in captivity (Oftedal and Allen 1996).

Due to the differences between wild and cultivated fruits it is therefore suggested the majority of a diet for captive chimpanzees should be vegetables. A high quality, high fibre pellet should also be fed providing approximately 30% of the daily energy (Plowman 2016). Browse should be provided every day, as much as is possible, to increase the fibre content of the diet. Food used for enrichment should be taken from the daily diet, and not as an added extra. Meat could be given as enrichment, but as most chimpanzee communities seem to hunt opportunistically, it is not necessary to provide meat daily. To provide variety seasonally, and daily, vegetables could be grouped into three categories – leafy greens, root vegetables and other watery vegetables. An example diet using these categories has been provided below. The nutrients provided by this diet are detailed in table 11, whereby the pellet is Dodson and Horrell primate browser and browse and meat/invertebrates are not included in the analysis.

Recommended diet quantities as a % of the diet (fresh weight).

- Pellet - 15%
- Leafy green vegetables - 50%
- Other vegetables - 20%
- Root vegetables - 13%
- Pulses – 2%
- Meat / invertebrates – could be given occasionally as enrichment but are not necessary daily.
- Browse - should be given as much and as often as possible.

2.2.3.4 Current examples

The following diets (tables 7-10) are currently fed to chimpanzees. Dietary analysis of these diets was conducted using nutrient values available in Zootrition (version 2.6) software. Nutrient analysis of these diets can be seen in table 11, and over 90% of all food items used in analysis had values for the nutrient categories reported. However, not all items were included in nutritional analysis such as browse, which will alter the nutritional composition of the diet, predominantly by increasing fibre content. Where food items are given in categories (e.g. leafy vegetables), the total amount given was split equally between 3 food items. The same items were used across the different diets to allow comparison.

Table 7: Diet A, the weekly diet sheet for 15 chimpanzees.

Food item on diet sheet	Food item entered into Zootrition	Amount given over the week
Swede	Turnip	35 kgs
Green beans	Green snap beans	25 kgs
Chicory	Cabbage	61 kgs
Tomatoes	Tomatoes	51 kgs
Eggfruit	Eggplant	35 kgs
Grapes	Grapes (1 bunch = 500g)	3 bunches
Yoghurt	Plain yoghurt (assume 1 litre = 1000g)	14 litres
Mixed seeds	Sunflower seeds (1 bucket = 1kg)	3 buckets
Celeriac	Celeriac	29 kgs
Pepper (green)	Green pepper	20 kgs
Cucumber	Cucumber	24 kgs
Carrots	Carrots	20 kgs
Courgette	Courgette	30 kgs
Pepper (red)	Green pepper	25 kgs
Boiled eggs	Boiled eggs (58g per egg)	28 eggs
Mung bean	Mung beans	9 kgs

Table 8: Diet B, the daily diet sheet for 3 individuals

Food item on diet sheet	Food item entered into Zootrition	Amount given per day
Soaked pulses	Mung beans	210g
Leaf silage (winter only)	--	300g
Granovit Zoo primate high fibre pellets	Granovit zoo primate high fibre pellets	1539g
Fruits (for training) apples, pear, banana, grapes etc	Grapes, apples and pear	300g
Tea and 2 spoons of honey (5 litres twice a week) (litre)	--	
Squeezed lemon or orange in water (5 litres twice a week)	--	
6 apples in boiled water and 1 spoon of honey (twice a week) (litre)	Apples (1 apple = 115g)	Equivalent to 99g per day
Bamboo branches, hay, alfalfa	--	Ad lib
Leafy vegetables – chicory, Chinese cabbage, cabbage, parsley, brussels sprouts, rocket, spinach, lettuce etc	Chinese leaf cabbage, cabbage, spinach	2305g
3 Boiled eggs (once a week)	Boiled egg (58g per egg)	Equivalent to 25g per day
Enrichment foods – pumpkin seeds, sunflower seeds, popcorn, peanuts, honey, nuts	Peanuts, sunflower seeds, honey	160g
Other vegetables – carrots, boiled potato, celery, sweet potato, courgette, tomato, peppers, beetroot, kohlrabi etc	Carrot, courgette, beetroot	1925g
Boiled rice / porridge / boiled corn meal	Brown rice	230g

Table 9: Daily diet sheet for one chimpanzee

Food item on diet sheet	Food item entered into Zootrition	Amount given per day
Fruit (apples, pears, kiwi, banana, orange, pineapple, grape, watermelon)	Grapes, apple and pear	2.4kgs
Vegetables (iceberg lettuce, kohlrabi, Chinese cabbage, tomato, bell pepper, celeriac, chicory, leek, cucumber, beetroot, celery, romaine lettuce, fennel, onion, white cabbage, broccoli, carrot)	Chinese cabbage, cabbage, carrots, beetroot, courgette, pepper	3.6kgs
Yoghurt	Plain yoghurt	40g
Boiled beef (once per week)	Beef	220g (equivalent to 31g per day)
3 eggs (throughout the week)	Eggs (58g per egg)	Equivalent to 25g per day
Reward food - banana pellets, nuts, grains	--	--
Enrichment	Twigs with leaves (Thawed during the winter)	--

Table 10: Diet D, daily diet for an individual chimpanzee at Wildlife Reserves Singapore.

Food item	Amount (g)
Pulse Mix	100
Pellets	48
A Veg	1400
B Veg	4000
C Veg	1500
Browse	100
Sugarcane	600
Fruits	400
Local Fruits	800
Meat	10 (once a week)
Eggs	10 (once a week)

Table 11: Nutrient analysis of all diets on a dry matter basis.

Nutrient	Diet A	Diet B	Diet C	Diet D (Nutrient analysis from Cabana, Jasmi and Maguire, 2017)	NRC chimpanzee recommendations
Ash %	6.90	8.85	4.67	7.3	
ADF %	10.56	14.87	6.71	-	5-15
NDF %	13.46	20.41	9.74	22.9	10-30
Crude Fat %	8.17	7.72	3.81	2.4	
Crude Protein %	16.63	19.53	8.94	19.8	15-22
Non-structural carbohydrates	54.84	43.49	72.84	47.5	
Calcium %	0.30	1.01	0.22	0.5	0.8
Phosphorus %	0.46	0.67	0.21	0.4	0.6
Metabolizable energy (ME) (kcal/g)	3.55	2.86	3.6	-	
ME total kcal per individual per day	1198	1933	2647	-	

Non-structural carbohydrate percentage (i.e., sugars and starch) were calculated using the following formula on a dry matter basis: total dry matter – crude protein – crude fat – ash – NDF (as used in Britt et al., 2015). To calculate the metabolizable energy per individual per day, the diets were divided by the number of individuals in the group. However, this does not account for sex or age differences that may have been adjusted for in the formulation of the original diets. Equally, weight and reproductive status for the chimpanzees in these groups are unknown and individual chimpanzees may not consume an equal amount of the diet. Nutrient levels may differ from those shown for diets where categories of food are given but only 3 items were used in this analysis.

NDF levels within the diet vary, with diet D providing the highest percentage of NDF, closely followed by diet B, and diet C providing the lowest. All diets however contain less than the

33.6% seen in wild chimpanzee diets (Conklin-Brittain, Wrangham and Hunt, 1998). Diets vary in crude protein and crude fat content and as a result non-structural carbohydrates also vary.

2.2.4 Diet reviews / monitoring

Regular and routine diet monitoring should take place through intake studies and nutrient analysis to ensure diets are appropriate. A comprehensive guide to conducting intake studies has been written by Fidgett and Plowman (2013) (see Appendix I).

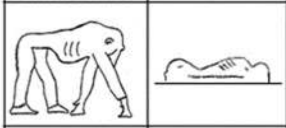
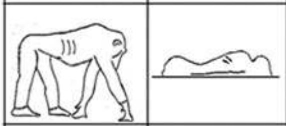
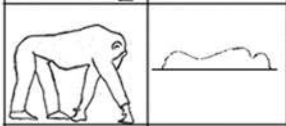
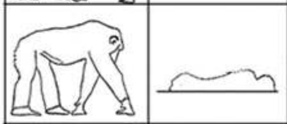
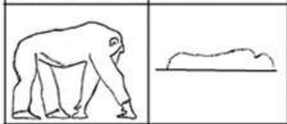
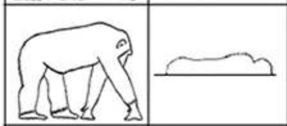
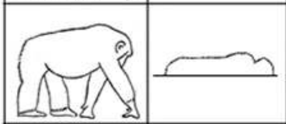
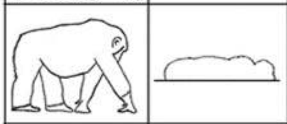
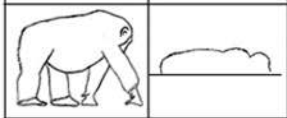
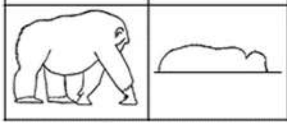
2.2.4.1 Body Condition Scoring

Body condition scoring (BCS) is another method of assessing animal health. Ideally BSC should be undertaken under anaesthetic to accurately assess condition (Clingerman and Summers 2005). However, visual BCS can be undertaken, as long as consideration for hair/fur/coat is taken. A study assessing female geriatric chimpanzee health used a 1-5 scoring system (Nunamaker Lee and Lammey 2012) with scores and definitions seen in *Table 12*. Clingerman and Summers (2005) published a BCS guide for primates using macaques as a model. This guide (see Appendix II) provides 9 score points between 1 and 5, with detailed definitions of each point. More recently, a ten-point scale for non-invasive observational ratings of the body condition was validated against actual weights and skin fold measurements from sedated chimpanzees and proved a reliable measure. (Reamer *et al.* 2020) *See Table 13*.

Table 12. `Table from Nunamaker, Lee and Lammey (2012), defining the chimpanzee body condition scoring system used in a study on female chimpanzee health.

Score	Description
1	**Very Thin.** Weight loss is obvious. Prominent bony structures. No discernable body fat and lack of muscle mass.
2	**Thin.** Minimal weight loss not a medical concern. Palpable ribs with no adipose tissue cover. Little discernable body fat. Minimal to no loss of muscle mass.
3	**Normal.** Ideal condition. Healthy. Ribs are not visible but palpable with slight adipose tissue cover. Excellent muscle mass with minimal body fat.
4	**Overweight.** Increased weight more than desired but not a medical concern. Ribs difficult to palpate. Obvious deposition of adipose tissue particularly in the abdominal area.
5	**Obese.** Increased weight more than ideal. Weight loss recommended. Ribs are not palpable. Obvious excess adipose tissue deposition and redundant folds of skin.

Table 13. Chimpanzee body condition scoring chart used for Sedated (right lateral top view) and In-group (ambulating) BCS. BCS, body condition score (Reamer et al. 2020)

AMBULATING / RIGHT LATERAL TOP VIEW	RATING	DESCRIPTION	DETAIL	
	1	Emaciated	extremely concave abdomen, thin skeletal face, arms and legs	
	2	Thin	visible ribs, very concave abdomen	Underweight
	3	Underweight	defined "v" back, concave abdomen, wrinkled skin around abdomen or limbs	
	4	Normal Low	abdominal tuck, thin thighs, could gain 5 lbs.	
	5	Normal	muscular body, some abdominal tuck, neither concave or convex abdomen	Normal Weight
	6	Normal High	normal body condition but may have slight convex or rounded abdomen, could lose 5 lbs.	
	7	Overweight	round convex abdomen, big thighs, possible fat around butt, could lose 10 lbs.	
	8	Obese	bigger abdomen that starts to extend outside of body frame, pectoral fat, flabby/fat upper arms, plump skin around ischial callosities	Overweight
	9	Morbidly Obese	very large abdomen that extends horizontally outside of body frame, fatty deposits underneath arm and possibly biceps as well as thighs	
	10	Extremely Obese	extremely large abdomen that extends horizontally outside of body frame, fatty deposits around neck and head, rolls of fat all over	

2.2.5 Feeding presentation

Studies in zoos have shown whole feeding provides a more equal spread of diet to all individuals (Sulawesi crested black macaques - Farmer *et al.* 2010; lion-tailed macaques – Smith, Lindburg and Vehrencamp 1989), increased foraging time in tapirs (Farmer *et al.* 2010) and decreased aggression and increased feeding time in coatis (Shora, Myhill and Brereton 2018). Therefore, feeding whole foods, rather than chopped, may increase feeding time and replicate wild manipulatory behaviours in chimpanzees also. Research by Bloomsmith and Lambeth (1995) has shown that feeding chimpanzees on an unpredictable schedule decreases inactivity behaviour directly before feeding, compared with feeding at a set time. Increasing activity levels is beneficial for captive chimpanzees, as they are often inactive more than wild chimpanzees (Bloomsmith and Lambeth 1995) and so changing feeding schedules may help increase activity levels.

In the wild, chimpanzees usually feed high in the canopy, with only 28.4% of feeding observations being recorded at ground level (Sabater-Pi 1979). The majority of their feeding time is spent seated (80%), with 15% of the time standing up and the remaining 5% of feeding time lying down (Sabater-Pi 1979). Chimpanzees are also suggested to feed relatively independently; approximately 2-3m away from other chimpanzees (Sabater-Pi 1979) therefore adequate space should be provided so chimps are able to eat independently should they wish too.

2.2.6 Conclusion

- Wild chimpanzees have a diverse diet and consume mainly ripe fruits. However, cultivated fruits are higher in sugar and lower in fibre than wild fruits so should be avoided when feeding captive chimpanzees.

- Not all chimpanzee communities hunt vertebrates and the nutritional impact of hunting is not yet fully understood. Similarly, the amount of invertebrate and animal parts consumed varies among wild chimpanzee communities but could be an important aspect of behaviour. It is therefore not required to regularly feed animal parts to captive chimpanzees, but these could be used for enrichment occasionally.

- Diets high in fibre, low in sugar and low in water soluble carbohydrates are ideal for captive chimpanzees and could help to reduce instances of regurgitation and reingestion and prevent diabetes and obesity. By providing browse daily, the fibre content of the diet can be increased and the feeding time extended.

2.3 Social structure

Raymond van der Meer, Karin Federer, Gerd Nötzold, Adrian Baumeyer

2.3.1 Basic social structure

Chimpanzees live in multi-male, multi-female groups that usually split up in smaller units over short periods within their territory and have a fission-fusion organisation. The males fight over dominance and get support from others by maintaining a complex social network of coalitions. Generally, females reaching puberty migrate out of the group, whereas males stay in their native clan during their entire lives. For more detail, please refer to 1.7.1. Social structure of these guidelines.

2.3.2 Social structure in captivity

Group structure in zoos should reflect the situation in the wild of communities with multi-male and multi-female composition. Therefore, the population is managed in a way that institutions keep more than one adult male chimpanzee in a group together with several adult females and their growing offspring (see Chimpanzee EEP Long Term Management Plan (LTMP), Carlsen *et al.* 2018). By housing chimps in multi-male and multi-female groups of different age classes the social, physical and psychological well-being of the animals is ensured and will allow a broad range of species-specific behaviours. Especially for male well-being, more than one adult male should be present in a group at all times. The size of groups held in captive environments will vary from institution to institution, and may be limited not just by facility size, but by the flexibility and complexity of the holding facilities. Chimpanzees should never be housed alone for any extended period unless it is deemed necessary for the physical or psychological well-being of that individual. At least mesh-wire contact (visual, auditory and tactile) with conspecifics should be possible.

Historically, many collections used to keep a single adult male with their breeding group, in order to avoid fights between the males. Today we know that for the well-being and the stability of the group it is essential to keep more than one adult male. Nevertheless, the old “one male” approach is still present in the minds of various collections and keeping multiple males is not without challenges. Males will compete and fight over status and access to females. However, large social groups tend to be able to deal with this and keep aggressiveness to an acceptable level. These groups tend to have less problems overall, if managed in a multi-male way (Experience from the EEP population from the last years, de Jongh & Carlsen, pers. comm.). Aggression is a natural part of a chimpanzee’s behavioural repertoire, and caretakers should monitor it closely. In most cases of aggressive behaviour, not intervening is most likely the best option. Especially when animals have the possibility to avoid each other and do fission-fusion by having access to complex enclosures. In certain cases, aggression can become very violent and males can kill each other. This is also observed in nature (Goodall 1986, Wilson *et al.* 2014, Pruetz *et al.* 2017). An intervention by animal keeping staff is indicated when fighting gets overly aggressive. Indications therefore might be: overt aggression against a single animal over an extended period (>5 Minutes); targeted individual(s) cannot escape or defend themselves, are ganged upon and no other group members try to dissipate the tension; when grievous injuries occur (i.e., amputation of whole limbs or similar); when submission signs by the target are ignored by the attacker(s) or attacker(s) go into a frenzy. Intervention or separation is not indicated once the fight is over. If an intervention ends with the separation of the targeted individual, it should be kept in safe mesh-wire contact and if possible, with another individual from the group. After a fight, the animals often engage in reconciliation and/or consolation behaviour. This is characterised by body contact between the opposing parties (reconciliation) or of the aggressed party with a third-party member (consolation). The behavioural patterns observed in these situations are: kiss (mostly for reconciliation), embrace (mostly for consolation), hold-out-hand, submissive vocalization and touch (de Waal and, van Roosmalen 1979). This behaviour is important to eliminate chances of additional conflicts and for resetting coalitions within the group. Caretakers should never prevent this by ending conflicts prematurely or separating conflicting parties (even if they want to prevent further conflicts). Chimpanzees heal extremely well and have a high tolerance of pain. Aggression can be reduced by providing larger space but more importantly, they should have opportunities to get away from each other, in other words, they need a complex environment.

Generally, the groups should be kept together 24 hours/7days and regular separation should be avoided. Nevertheless, as chimpanzees live in a fission-fusion system, enclosures should offer possibilities to the animals to separate themselves for short periods from the group by providing a complex environment. This is also helpful for managing aggression. Furthermore, the natural behaviour of separating from the group can be exploited to separate individuals or compatible subgroups over short periods for management reasons. Several situations might warrant such a short-term separation. For instance, low ranking females separate for giving birth (to increase survival chances of new-borns), a male and female separate together in consort-ship for mating (for giving specific males the possibility to breed), an oestrus female separates for extra-group mating (give males from other groups access to breeding) or several females with young offspring separate (to create a more secure environment for young chimps to play freely). All these situations can be recreated in captive management, if the animals are used to it by regular application and appropriate training periods. Optimally the animals can indicate themselves if they prefer a separation or want to stay in the group. Only special situations (medical or extreme behavioural problems) should entail a longer separation of individuals. We would like to point out, that aggression among males is not, as a principle, one of these. Leaving the individuals in a group and letting them sort out their relations, generally leads to more stable groups in the future.

2.3.3 Age structure

Captive chimpanzee groups should preferably reflect the age structure of wild groups (Goodall 1986; Matsusawa *et al.* 2011; Nakamura *et al.* 2015). Meaning that all age classes should be represented in a group, with the younger age classes being more common than the oldest age class. It is important to have older animals in a group in order for the younger individuals to learn the skills and social behaviour necessary for leading a life as a socially competent chimpanzee once they reach adulthood (Pruetz and McGrew 2001). This is true for both sexes. Besides basic behaviour, there are sex specific skills they will learn from older individuals. Females learn the necessary skills as future mother from observing other females caring for offspring and from being allowed to carry younger siblings under the supervision of their mother. Males learn how to function in multi-male situations and being able to navigate the complex male coalition networks. This ensures that the future generation of adult chimpanzees will be capable of functioning in captive social groups and ensure their wellbeing.

Furthermore, offspring is important for the wellbeing of all individuals in a group. In nature, females generally have offspring during their adult life. For females, caring for offspring is one of the fundamental behaviours that they should be able to express in a captive environment. Meaning that all females should breed regularly with due respect for management decision related to different taxonomic subgroups (Carlsen *et al.* 2018). If population management requires a smaller growth rate of the population, females should not be prevented entirely from breeding but birth intervals can be extended – e.g. by contraceptives.

In general, offspring is vital for the whole group, as all group members profit from the activity and enrichment young individuals provide and dealing with them is part of their natural behaviour.

2.3.4 Changing group structure

2.3.4.1 Male bachelor groups

While mixed groups are recommended for chimpanzees in a captive environment, there is some positive experience and need for the formation of male bachelor groups (Valleé des Singes in France, Hilvarenbeek in The Netherlands, and Monkey World in the UK). Bachelor groups generally consists of males of similar age (juveniles, adolescents or adults) and size (as described in Fritz and Howell 2001) or of individuals that know each other well, i.e., coming from the same group. Otherwise, setting up a bachelor group of various individuals needs to be monitored closely and enough time should be given for the introductions (existing example at Monkey World in the UK). In order to reduce aggression amongst the males, it is recommended that such groups are housed outside the visual and olfactory range of females. We do not know what the maximum number of adult males are that can coexist with each other in a stable bachelor group but in theory there is no limit. The biggest bachelor group in Europe at the time of writing this consists of ca 14 males (Monkey World, UK) and more males could be added to this group (refer to chapter 2.7 of these guidelines for details on introduction). In addition, we do not have enough data on how these bachelor groups differ behaviourally from multi-male/multi-female groups. Research suggests that in the wild, males are more social, and act as groups, while females tend to be alone with their offspring or only with one or two good friends (Mitani and Amsler 2003). This indicates that females play a secondary role in the functioning of a social group or might even be disruptive in some situations. In a captive environment, more research on bachelor groups is needed to answer this question.

2.3.4.2 Female transfers

At study sites across Africa, males stay in their natal community and cooperate in territory defence against neighbouring communities. Females, in contrast, usually disperse at 10–12 years of age, around the time they reach sexual maturity. Where contiguous habitat still exists, as at Mahale, Tanzania and Taï, Cote d'Ivoire, most females disperse (Nishida *et al.* 1990; Boesch 1997). Although many zoos report problems with having more males in a group and want to send away males, the EEP is implementing with its long-term management plan (Carlsen *et al.* 2018) to keep males in their native group and exchange females among groups. In line with the situation in the wild, females should preferably be exchanged around the time they reach maturity, which is earlier in captivity than in the wild (around 9-10 years of age).

2.3.4.3 Male transfers

In nature, males do not disperse but stay in their native group (see above). In the captive population, historically, male transfers were common but should generally be avoided under the new long-term management plan of the EEP (Carlsen *et al.* 2018). However, there are situations where male transfers might be needed and special care should be taken when doing male introductions (For more detail please refer to chapter 2.7 of these guidelines).

2.3.5 Sharing enclosures with other species

The only attempt to have chimpanzees share their enclosure with other species that the EEP is aware of is that of a safari park that kept hippos and Californian sealions in a very large pond while chimpanzees lived on a relatively small island of the same pond. The species could easily avoid approaching each other. We have no information on the experiences with this combination but would not recommend trying this again.

It is not recommended to have chimpanzees share their enclosure with other species.

2.4 Breeding

María Teresa Abelló, Veronica Cowl, Yedra Feltrer, Lars Versteege

2.4.1 Breeding

Historically, in captivity, most chimpanzee groups consisted of only one breeding male with several females, completely against the nature of this species as chimpanzees in the wild live in multimale - multifemale societies. A progressive change in captivity is to create also multimale groups in which males (as well as females) work to improve their position in the hierarchy, and the right to mate. In general, the dominant males will mate the females of their group, but cases of "sneaky copulations" have been described, where subordinate males manage to copulate with females out of the sight of the dominant male(s). In some cases, the alpha male may tolerate copulations from certain other males. This can particularly take place if the "alpha position" depends on a coalition with one or more other males. Tolerance is greater in the periods before and after peak tumescence.

2.4.1.1 Mating

See also Chapter 1.6. Reproduction and life history.
Male and female chimpanzees reach puberty at 7–8 years of age in captivity. Maximum life span in zoos is around 60 years.

In the wild, females exhibit their first oestrous swelling when they are 8.5-9.5 years old (Tutin 1980). In Zoos this may be a bit earlier, but not much. Although menarche typically does not occur for 1-1.5 years after the first swelling, chimpanzee females in zoos have given birth as early as 5.6 years of age, which however is an exception (Earnhardt *et al.* 2003). The normal (menstrual) cycle is 35 days, with a 72-hour menses (see also chapter 1.6 Reproduction and life history). Haematuria can often be noted when overt blood flow is visible on the external perineum of the chimpanzee or on the floor or other surfaces of the housing area. However, in many cases it can only detected by reagent strips, and this method may be used to track cycles for individual females (Lacreuse *et al.* 2008). Sexually mature female chimpanzees also develop marked swelling of the perianal and perineal tissues due to interstitial fluid accumulation that fluctuates with hormonal influences. This genital swelling (intumescence) increases to peak size and turgidity during the follicular phase of the cycle. Perineal intumescence is a distinct visual marker of receptivity and potential fertility (only during peak swelling) with marked impact on socio-sexual behaviour. During the peak swelling, females demonstrate more assertive behaviour. Young adolescent females are more likely to solicit copulation than are older females. Oestrous swellings are highly attractive to male chimpanzee, and males tend to spend a significantly increased amount of time in proximity to females that are swollen.

Copulation may occur at any time during the female's oestrous cycle, including during pregnancy and menstruation. In addition to the degree of the female's swelling, other factors may also influence the likelihood of copulation, such as age, time of day, and level of excitement. Either sex may initiate copulation, but it is most commonly initiated by males in both the wild and in zoos. Copulation strategies by the males vary but may include "consorting" with a female out of sight of the rest of the group. Group males of all ranks interact preferentially with intumescent females and their offspring. Competition between males, concurrent with agonistic behaviours, will occur with increased frequency in the presence of cycling females.

It is common that the dominant male(s) monopolise a female in oestrus to avoid the subordinate males mating. This situation can trigger aggression between males, especially if there is no strong coalition of dominant males. A single dominant male might not be able to resist all subordinate males to gain access for mating.

2.4.1.2 Pregnancy

It is advisable to monitor the female(s)' cycle by daily observing and recording their swelling. This can help to early detect a pregnancy. Pregnancy test using urine may be done with human test kits.

Pregnancy can be confirmed using ultrasonography after four months, but it is only advisable in case it's possible though training; otherwise, it is not advisable. It is better to repeat the test over the next months and monitor that the animal is fine, and her belly is growing accordingly.

Pregnant females should be maintained with the group throughout the pregnancy under normal circumstances. Managers should monitor the behaviour of the group towards the pregnant female as the pregnancy advances.

Natural conception is the recommended form of conception for chimpanzees although artificial insemination (AI) techniques have been successfully implemented with this species (Martin *et al.* 1978, Matsubayashi *et al.* 1985) including conception from cryopreserved sperm collected post-mortem (Kusunoki *et al.* 2001), the techniques need further development and implementation. To achieve an easy methodology could favour an improvement on population management to the benefit of both demography and genetic variability.

2.4.1.3 Contraception possibilities

The decision to perform any kind of contraception should be made in coordination with the EAZA Chimpanzee EEP. Please report all contraceptive use to the EEP Coordinators and to the EAZA Reproductive Management Group (EAZA RMG, formerly EGZAC), either by email or through the Contraception Database online survey https://eazarmg.org/ after registering as a user. You then have access to more sections where you can enter your data.

The three general approaches to prevent reproduction are:

1) separation of the sexes
2) reversible contraception
3) permanent sterilization

As chimpanzees are a social species, separation of the sexes is not generally recommended, but by recreating the natural fission-fusion system (temporarily separating selected males/females in order to avoid breeding) one can guide selected breeding slightly.

The following information summarizes reversible contraception and permanent sterilization methods for chimpanzees. More details on products, application, and ordering information can be found on the EAZA RMG website APPENDIX.

Surgical sterilization can provide an effective, low cost, but irreversible form of contraception; however, in many cases a reversible short-term method may be preferred. Reversible contraceptives such as implants, pills, injectables and intrauterine devices (IUD), can provide control of reproduction with select individuals while maintaining species-typical behaviour within a group. Not all reversible contraceptives permit the maintenance of normal behaviour. It is important to balance the efficacy, safety, and method of delivery for a contraceptive with the animal's age, reproductive status, and the potential ramifications of the regimes on social behaviour (Bettinger and DeMatteo 2001). Because of the profound effects on the normal socio-sexual behaviour of chimpanzees, genital swelling **should not be completely eliminated** by the contraceptive option selected. In considering contraceptive options, both genders should be evaluated to permit prevention of pregnancy while minimizing impact on group behaviour. It is important to consider the reversibility and safety of these options as well as the tendency of weight gain observed with the hormonal methods of contraception. A comprehensive summary of the methods of contraception available follows.

2.4.1.3.1 Permanent (surgical) sterilization

- **Vasectomy (males only)**: A scrotal or pre-scrotal / inguinal approach may be utilized. The scrotal approach is easier; however, the inguinal skin appears to be less sensitive and if the incision is made in this location, great apes appear to less likely traumatize the incision postoperatively. It can be challenging to identify the vas deferens and distinguish it from other structures, thus it is wise to submit the removed reproductive pieces for histologic confirmation. Sperm granulomas have been reported following vasectomy. Ligating or hemoclipping the vas on both ends should minimize the risk of granuloma formation but will reduce the successful reconstruction surgery when needed. Cutting out 1 cm and folding both loose ends over and ligate them will also avoid the risk of spontaneous reversal because of recanalization of the vas deferens Thus the open-ended vasectomy makes it more easily reversible. Following vasectomy, males remain fertile for 3-4 weeks. This procedure should not be undertaken in individuals who are likely to receive breeding recommendations as reversals are unlikely.

- **Castration (males only)**

  Permanent sterilisation by surgical gonadectomy. Castration is most easily performed through bilateral transverse scrotal incisions. This procedure should not be carried out in individuals who are likely to receive breeding recommendations again at some point. As the testes are removed, testosterone mediated aggression may decrease. Males may also experience a decrease in body mass after castration. If pre-pubescent males are castrated, they may become taller due to the delay in the closure of the epiphyseal plates. Due to the social system with multi-male multi-female groups, the surplus of males is not an acute problem and the Chimpanzee EEP does not recommend castration.

- **Tubal ligation (females only):** Tubal ligation is preferred to ovariohysterectomy. If there is any chance that the procedure may need to be reversed in the future, it is best not to remove a section of the oviduct and only apply a clip or ligature to it; however, with this technique there is a greater possibility the procedure will fail and the animal will become pregnant. Vasectomy (males only)

2.4.1.3.2 Reversible contraception

- **Progestogen-based contraceptives (females only)**
  - **Oral combination birth control pills (various brands) (females only):** Use of birth control pills in apes is compromised by the difficulty in ensuring an animal's complete compliance with accepting and retaining the proper dose**, for this, crushing of the pills and administering with liquid to drink is the most efficient way**. Human birth control pills are available in different formulations of combined synthetic oestrogen and progestogen. The human regimen for most formulations is 21 days of hormone treatment and 7 days of placebo, which results in withdrawal bleeding similar to menstruation. Most apes, contracepted with oral birth control pills, have followed the same regimen. However, as chimpanzees have a longer cycle than 28 days, some have received hormone for 28 or 35 successive days rather than 21, to more closely match their normal cycle. If oestrus behaviour is not desired, the placebo can be skipped, and the pill may be given 3-6 months continuously.

    When starting oral birth control pills, remember that it may take some time until full effectiveness. However, experience from women suggest rapid effect within a few days using oral hormones. As an extra precaution, gender separation may be necessary for 2 weeks. In bonobos, breakthrough bleeding on lower oestrogen dose oral birth control pills has been reported (Agnew *et al.* 2016). To avoid oestrus behaviour and side effects, progesterone -only pills may be preferred over combination pills.

  - **Progesterone-only pills (females only)** (several brands for human use, "mini-pill") are indicated in pubertal, juvenile, older and lactating females when necessary because the mini-pill is not associated with thrombosis and heart disease. The mini-pill has no break and must be given every day at the approximately same time. If contraception of females who have recently given birth is required, the mini-pill could be used but not for at least 1 month following parturition to allow for uterine involution. In most cases however, if females are nursing, contraception will not be required for at least 1 year following parturition.

  - **Etonogestrel (Implanon/Nexplanon®) subcutaneous implant (females only):** one unit is recommended to be implanted, although an increased dose may be required in heavier individuals. It is strongly recommended to place implants subcutaneously in the inner arm or another area where the implant can be easily found for removal; removal of implants is necessary to achieve full reversibility. In primates, the implants usually last between 2-3 years however this varies from individual to individual. If implants are left in place, chimpanzees have been suppressed for at least 2.5 years, but in some cases up to 10 years. Implant removal in these cases causes an immediate return to fertility. Implants should be placed in locations with thin skin (armpit or inner arm recommended in primates). Data from the EAZA RMG Contraception Database also demonstrate a 61% reversal rate in female chimpanzees given breeding opportunities. The mean time to reversal following Nexplanon is 57.4 months (range: 30.1-126.3 months), including cases where the implants were and were not removed. In cases where implants were removed, reversal rates increase to 67%, and time to reversal decreases to 11.6 months from the date of implant removal (range: 1.2-36.6 months). Where implants were left in place, reversal rates are 57%, with a mean time to reversal of 71.2 months to reverse (range: 30.2-126.3 months). Time to reversal will vary across individuals, but initial data indicate that implants should be removed when replacing contraception or if individuals receive a breeding opportunity.

There may be a low level of follicle production whilst on Implanon/Nexplanon which can stimulate sexual behaviour or signs of oestrus such as skin swelling. If issues related to swellings occur, the dose can be increased to 1 ½ rods. Knowing whether the female is therefore sufficiently contracepted is a challenge. Females may show oestrus and may copulate but should not be able to conceive. Monitoring sexual swellings throughout the contraceptive period is therefore recommended. If swellings are inhibited and then restart, please ensure the implant is still in place. If swellings increase and the implant has been in place for a minimum of two years, replace it with a new one if reproduction is not desired. Implanon/Nexplanon will also thicken cervical mucus; if ovulation does occur, sperm transport and/or implantation is inhibited. Please be aware that while both Implanon and Nexplanon have the same active ingredient and formulation, Nexplanon implants are coated with a radio dense matrix that facilitate the locating of the implant using radiographs.

- **Medroxyprogesterone acetate (Depo-Provera®) intra-muscular injection formulation (females only):** Administration of this synthetic progestin is by injection, which may involve the use of darts to administer the drug or an anaesthetic event. The recommended dose is 2.5-5mg/kg body weight every 2-3 months. Care must be taken to ensure administration of the full dose. Latency to effectiveness is approximately 1-3 days. However, it is recommended that sexes are separated for one week or the first bout must be supplemented with additional contraception for 7 days. Depo-Provera is designed to be fully reversible and time to reversal varies greatly among females, although the average duration is 3 months it can be as long as 2 years. As Depo-Provera is not an implant you will have to wait for the drug to clear from the individual's system and this length of time can vary between individuals and is unpredictable in some cases. The effects of long-term administration of Depo-Provera are not completely known, and there may be a deleterious effect on the endometrium following prolonged use. Depo-Provera should therefore be used as an interim contraceptive method. A side effect of Depo-Provera is that females may develop male secondary sex characteristics and there may be an increase in aggression.

- **Levonorgestrel implant (Norplant 2®/Jadelle®) subcutaneous implant (females only):** two rods are recommended to be implanted for this species. It is strongly recommended to place implants subcutaneously in the inner arm where the implants/rods can be easily found for removal; removal of implants is necessary to achieve full reversibility. In primates, Jadelle usually lasts for 4 years. However, this can vary on an individual basis. Although unlikely (as it is more potent than Implanon), there may be a low level of follicle production which can stimulate sexual behaviour or signs of oestrus such as skin swelling. Knowing whether the female is therefore sufficiently contracepted is a challenge. Females may show oestrus and may copulate but should not be able to conceive. Monitoring sexual swellings throughout the contraceptive period is therefore recommended. If swellings are inhibited and then restart, please ensure the implant is still in place. If swellings increase and the implant has been in place for a minimum of two years, replace it with a new one. Norplant is designed to be fully reversible; however, for full reversibility the rods must be removed. The potential long-term side effects of progestogens have not yet been fully evaluated.

- **Gonadotrophin releasing hormone (GnRH) agonists (males and females)**

  GnRH agonists, such as Deslorelin (Suprelorin®; guideline below) or leuprolide acetate (Lupron®), reversibly suppress the reproductive endocrine system, preventing production of pituitary hormones (follicle stimulating hormones, luteinizing hormone) and gonadal hormones (oestradiol and progesterone in females, testosterone in males). The observed effects are like those following either ovariectomy in females or castration in males but are reversible. GnRH agonists first stimulate the reproductive system, which can result in oestrus and ovulation in females or temporary enhancement of testosterone and semen production in males. The stimulatory phase can be prevented in females by treatment with an oral progestogen for 2-3 weeks. This method has not been used to date in bonobos for the potential social disruption that full suppression may cause and only limited experience with this method is available for other ape species.

  - **Deslorelin acetate (Suprelorin®) subcutaneous implant (males and females):** 2 x 4.7mg implants are recommended for a minimum duration of 6 months and 2 x 9.4mg are recommended for a minimum duration of one year. Up to three implants have been used in some cases if sexual behaviour or characteristics are not fully suppressed. Due to the initial stimulation of the reproductive system, the first bout in females must also be supplemented with additional contraception e.g., oral megestrol acetate (Ovarid®/Megace®) daily 7 days before and 8 days after placing the implants, or by continuing to administer birth control pills after implant placement. In males, the stimulation period cannot be suppressed therefore additional contraception should be used in females for 6-8 weeks after implant placement, to allow for viable sperm to clear from his system. Suprelorin is designed to be fully reversible. In order to increase the chances of a full reversal, place the implant in such a way that facilitates removal e.g., in the umbilical region, inner thigh, armpit. In contrast to Nexplanon or other progesterone implants, the Suprelorin is not made to be removed and the rod becomes brittle, which may make the localisation difficult. Repeated use of Suprelorin in females can prolong the effect of gonadal suppression. In some anecdotal reports, permanent ovarian suppression was seen after two consecutive implants.

- **Intrauterine device (IUD) (females only):** Physical considerations suggest the use of an IUD recommended for use in the human nulliparous female (i.e., the smallest size). Use of an IUD is complicated by the potential for removal of the device by the animal, a possibility mitigated by shortening of the removal strand. This, in turn, makes removal of the device when desired more difficult. Further, complications may arise if a pregnancy occurs with the presence of the device. Limited experience suggests a failure rate of approximately 5%, which is not dissimilar to the rate for human females (Nadler *et al.* 1994; Porteous *et al.* 1994).

2.4.1.3.3 Non-contraceptive effects

Weight gain is a common side effect associated with synthetic progestogens and GnRH agonists, but less so with combination oral birth control pills. Because obesity can have serious health consequences, weight should be carefully monitored, and diet managed as necessary.

2.4.1.3.3 Reversibility

Extensive data from humans and limited data from the EGZAC and AZA Reproductive Management Centre Contraception database indicate that oral birth control pills and the synthetic progestogen products should be reversible in apes. Implants must be removed if individuals receive a breeding recommendation or when new implants are inserted.

In general, the use of the pill is better, as it is an easy method to dispense in chimpanzees and great apes in general. Its reversibility is usually quite fast, and it is the preferred method. In cases where a long time without reproduction (more than two years) is necessary implants can be used

2.4.1.3.4 The preferred method

In summary the preferred method in females is through modern human contraceptive pills (if the ape will it take reliably) or through subcutaneous progestogen-based implants. In males, reversibility remains problematic and great caution must be exercised considering possible future breeders. Such methods should only be used with the approval of the EEP because reversibility might be difficult and is not warranted.

2.4.1.4 Birth

The first parturition is generally at 13–14 years of age, but it can be as early as 9–10 years in the wild. Chimpanzees reproduce throughout the year. Gestation is about 230 days. The norm is a single infant, but occasionally twins are born. Offspring are typically weaned at 4–5 years of age. The inter-birth interval in situ averages 4.6–7.2 years when the preceding infant survives (Williamson *et al.* 2013). Females can remain reproductive into their late forties and in rare cases even early fifties.

Some behaviours can be the clue to know parturitions is closer: female socially separating from the group, becoming irritable, less active and changing eating patterns, but not always these behaviours appear.

In most circumstances, the birth of the infant should occur in a familiar environment and with the social group present. However, one of the problems in the population is that besides very limited reproduction, there is a very high perinatal and juvenile death rate. Among the main causes for this is infanticide, both by males and by females. This is a known phenomenon in chimpanzees, also in the wild, but the possibilities for females giving birth and/or carrying very young offspring to avoid or limit the risk on infanticide are not favoured by the conditions in our zoos. We need to address this.

Facilitating fission-fusion is one of the ways to improve the survival changes for new-borns, but since this is not possible in all institutions, separating a female that is considered to have a high chance of being targeted, preferably from long enough before the expected birth to be comfortable by the time of the birth seems an option to consider, if only to gain experience with such a method (Nishida *et al.* 1990, Nishie and Nakamura 2017, Townsend *et al.* 2007, Otali and Gilchrist 2006, Lowe *et al.* 2018).

The presence of youngsters and adolescents may increase the risk of aggression to the new-born but the benefit of reducing social stress most often outweighs that risk and it is strongly recommended that the female remain with other conspecifics if at all possible. If the possibility of risk for the infant is really high, even more in the case of primiparous, in these cases to keep the female away from the group but with the company of a closer familiar or friend until the maternal behaviour is settled in a few days can favour a good development of this behaviour and avoid the infanticide risk.

An over-abundance of bedding material should be provided around the time of parturition and maintained at a high level throughout the first year as mother-infant nesting is particularly important. The temperature of the facility should be carefully monitored, and colder microclimates should be eliminated when possible.

2.4.1.5 Hand-rearing

Hand-reared individuals usually show a deficit in social and breeding behaviour. For that reason, it is recommended that in all circumstances, chimpanzee mothers have the opportunity to rear their infants themselves and without human intervention and that hand-rearing is only considered as a last resort.

In case that a female has already failed with rearing her offspring in several occasions, contraception should be considered in consultation with the coordinators while this female is placed in a situation where to learn and improve her maternal skills is possible.

If hand-rearing has been approved by the species coordinators (which is not uncommon in the Chimpanzee EEP due to the urgent need for breeding, meaning every offspring counts) in case of maternal abuse, neglect, or significant illness or injury to the mother or infant, and going to be applied where the life of the mother or infant is in danger, an early integration plan needs to be designed to avoid the secondary deleterious effects of hand-rearing.

In some circumstances, it may be possible to reintroduce the infant to the mother soon after the initial separation, and mother-rearing or supplemental rearing may be continued. If this is not the case, and hand-rearing is necessary, then it is important to re-socialize the infant with other chimpanzees as soon as it is safely possible. Ideally, this would be with a surrogate mother in the natal group, but it is also possible that an unfamiliar surrogate could suffice (Abello 2012, De Waal 1980)

In many cases, the adequacy of the mother's care is not clear. Institutions should stay in close contact with the EAZA Chimpanzee EEP to receive advice on whether particular behaviours are deemed enough to pull the baby into a temporary human-rearing situation.

New mothers may not want to carry the baby all the time and will occasionally put the new-born on the ground by itself. While this behaviour is not preferable is does not necessarily brand the mother as neglectful. Note how the mother reacts when the baby cries or is in apparent danger (perhaps due to proximity to another chimpanzee). If the mother returns to collect the infant in these circumstances, there is reason for optimism. If the infant appears not to be getting fed on a regular basis (once every 1-3 hours), there may be reason to supplement his diet by bottle-feeding through the mesh if possible. In one recent case, a mother ignored her new-born and as a result the infant was not getting fed enough. The mother was anesthetized, and the infant placed on the nipple. When the mother awoke, the bond was established and there was no need for human rearing intervention (S. Tanner, personal communication).

A hand-rearing protocol should meet both the physical needs of the infant as well as the psychological and social needs of the infant (Porton 1992). In general, the recommendations for hand-rearing an infant chimpanzee require:

- 24 hours' care
- Rearing in the presence of conspecifics for early reintroduction
- Species-specific handling of infant (mimicking a mother chimp)
- Institutional commitment to follow through with the rearing process until full re-integration is complete

For additional information see Appendix V EAZA Great Ape TAG Hand-rearing statement on the hand-rearing and early integration of infant apes:

2.4.1.5.1 Socialisation and reintroductions:

It is crucial for a hand-reared infant to develop a normal repertoire of species-appropriate social behaviours early on. The age at which to introduce an infant to a potential surrogate will vary with the infant's health and personality, as well as the surrogate's health, personality, and maternal skill. This introduction can occur as early as 3 months of age, and it is important to begin always before the infant is six months old when there is higher tolerance from adults towards infants and vice versa. Before this time, the infant will likely have to be reared by human caregivers.

Key points for the process:

1. The habituation to the new surrounding and keepers that should be done to get the young animal well adapted. Audio-visual contacts with conspecifics are to be initiated from day one.

   It is advisable to have the chimpanzee taken care of by several keepers to stimulate an easier transition to a surrogate. It is advisable to transport the baby hanging on keepers' clothes as much time as possible while doing their tasks for a good locomotive stimulation and emotional support. When the baby is left alone, a security blanket should be provided.

2. The interest and behaviour showed by the different individuals towards the baby may help to identify which animal could be the best surrogate.

3. A stable group with other infants is an advantage.

4. The potential surrogate should be an experienced mother. It simplifies the process of introduction, when the potential surrogate is high-ranking and can be separated from the group by oneself or with another group member.

5. Once the surrogate/s has been identified, the contact between surrogate and baby must be intensified. At the same time, the baby should be habituated to be bottle fed through the mesh (can be started with two months of age), as this would be necessary when the young would have been introduced and living with the group (Abelló 2012).

Even when all the requirements for a good introduction are satisfied, to do an early introduction presents always some risk. Keeper's attitude and their experience are also a very important factor for the success.

2.4.1.6 Development and care of young

In the wild, female chimpanzees maintain close relationships with their offspring for a relatively long period of infancy and juvenile development. Most mothers have their infants in constant, or nearly constant, contact until the infants first break contact with the mother between 6-12 months. Around 4-5 years of age, youngsters begin to sleep separately from their mothers, and will forage independently (Clark 1977). However, the maternal bond remains strong for many more years, and young chimpanzees will maintain a close association with their mothers until the age of 8-11 years when they achieve some degree of adult-like independence.

In the wild, offspring may typically stay with their mothers for at least six years, sometimes longer. At the age of adolescence, females may transfer from one community to another. In zoos, it may be easier to introduce a young female developing her first sexual swellings to a new group before she is at the age where established females may consider her "competition" for the males' attention, but this may depend individually. It is also important to remember the potential threat from the resident adults if the young female is carrying an infant when she is introduced (there is a risk of infanticide). In addition, an adolescent male may be considered a threat to an adult male as well. The transfer of males between 7 and 12 years of age should be avoided for that reason

Adult males are considered as extremely difficult but not entirely impossible to be introduced into groups with resident adult males. In the natural social system of this species, males never migrate between communities. So, any male transfer is unnatural and challenging. If breeding recommendations call for the emigration of a chimpanzee male from one group to another, based on the personalities of the individuals concerned a choice should be made between the transfer of a fully adult male, a juvenile male (5-7 yrs.), or even a juvenile male in the company of his dam. A young male can possibly be transferred and introduced in a new group by the age of 5-7, when he is still considered juvenile, and his presence may not seem so threatening (McNary 1992). When the transfer of a juvenile male together with his dam is considered, the possibility of infanticide should be taken into account and for this reason the young male should at least be 4 years old.

In all cases, the relative risks of the social introduction should be weighed against the relative benefits for both the immigrant and resident individuals and the personalities of all the involved individuals and the individual circumstances should always be carefully considered.

The recommended age of transfer of young females is 9 years. Chimpanzee communities in the wild are frequently multi-generational. In zoos, we should try to mimic this natural chimpanzee community including migration of young females to other groups while males stay in the natal groups.

2.4.1.7 Assisted reproductive techniques

The practical use of artificial insemination (AI) with animals was developed during the early 1900s to replicate desirable livestock characteristics to more progeny. Techniques used to preserve, and freeze semen have been achieved with a variety, but not all, taxa and should be investigated further.

Chimpanzees have been bred using artificial insemination techniques (Martin *et al.* 1978, Matsubayashi 1985) including the use of frozen sperm collected post-mortem (Kusonoki *et al.* 2001). The EAZA Chimpanzee EEP is supportive of institutional efforts to facilitate artificial insemination, especially with unrepresented individuals or individuals that are difficult to transfer. Semen is preferably collected using trainable methods such as an artificial vagina (Bowsher *et al.* 1992) or masturbation by positive reinforcement techniques. Alternatively, electro-ejaculation during full anaesthesia is possible.

2.4.1.7.1 Reproductive hormone monitoring:

Chimpanzees exhibit an approximately 35-day menstrual cycle that can be monitored by two external features: genital swelling and menstrual blood (Yerkes and Elder 1936; Elder 1938; Young and Yerkes 1943; Graham *et al.* 1972; Nadler *et al.* 1985). The genital swelling, which encompasses the labia and perianal region, results from an accumulation of interstitial fluid (Yerkes and Elder 1936; Clark and Birch 1948) and fluctuates in size and turgidity in response to changing levels of ovarian hormones (Allen *et al.* 1936; Fish *et al.* 1941; Clark and Birch 1948; Graham *et al.* 1972; McArthur *et al.* 1981; Nadler *et al.* 1985). Menstrual bleeding, which lasts about 3 days, may be observed by close visual observation of the labia or by traces of blood on the floor or nesting materials. The use of a Hemastix ® (blood test) ® to detect haemoglobin in a urine sample can confirm menstruation; however, due to the sensitivity of this test, false positives may occur (Bettinger and DeMatteo 2001). Approximately 10 days before the mid-cycle oestrogen peak, the genitals swell to maximal size and turgidity. The luteinizing hormone (LH) surge and ovulation occurs during the last 1-2 days of the maximal swelling (Elder 1938; Graham *et al.* 1972; Graham 1981; Nadler *et al.* 1985) and may be detected by urinary LH test developed for humans. Regression of the genital swelling is usually associated with decreasing levels of oestrogen and increasing levels of progesterone (Graham *et al.* 1972; McArthur *et al.* 1981; Nadler *et al.* 1985).

See also Appendix VI, Practical guide for the collection of urine samples from chimpanzees for monitoring female reproductive status.

2.4.1.7.2 Gamete recovery

While the technique is further developed, the EAZA Great Ape TAG asks and recommends providing germplasm to the EAZA Cryobank.

In case of interest to apply assisted reproductive techniques please consider the "**Great Ape Gamete Recovery Initiative**" (Lüders and López Bejar 2018). The aim of this initiative is to cryopreserve sperm (or recover oocytes/ovarian tissue) from certain individuals, to store viable genetic material and enhance genetic diversity within the Great Ape EEP´s in the future. Semen may be collected by training for ejaculation or during full anaesthesia by electro-ejaculation. Gametes (=sperm or oocytes) may be recovered post mortem or after castration from the epididymis or the ovary, respectively.

We strongly advice to contact the species coordinators and reproductive advisors for detailed information prior to any planned procedure.

In case a male general anaesthesia or castration is planned, euthanasia is scheduled, or an animal dies unexpectedly, we also ask to inform one of the following Great Ape TAG reproductive advisors for further advice:

- Dr. med. vet. Imke Lüders, European Veterinary Specialist in Zoological Medicine (Zoo Health Management).

- Manel Lopez-Bejar, Facultad de Veterinaria, Universitat Autonoma de Barcelona.

2.5 Environmental enrichment for chimpanzees

Barbara Regaiolli and Caterina Spiezio

2.5.1 Environmental enrichment and the welfare of zoo chimpanzees

Physical and psychological welfare is important for zoo animals and for conservation efforts, as poor welfare might lead to stress, suppression of immune function and decrease of breeding success (Wingfield and Sapolsky 2003; Morgan and Tromborg 2007). Moreover, healthy animals performing natural behaviours are necessary to obtain valuable information on the behaviour of their wild counterparts and to educate the public about their natural habits (Fernandez *et al.* 2009).

The performance of species-specific individual and social behaviours has been found as a positive welfare indicator in a growing body of research (Bracke and Hopster 2006; Hill and Broom 2009). The wider the variety of behaviours performed by an individual, the better the welfare. In particular, the behavioural parameters involved in the welfare assessment might be social interactions, problem solving abilities, the presence of species-specific and abnormal behaviours (Hosey *et al.* 2013). Environmental enrichment is the provision of behavioural stimuli, additional to the stimuli already provided in the facility where animals are housed and to the standard husbandry and management. These additional stimuli are intended to compensate the relatively stimuli poor conditions in human care as compared to those that the wild habitat is providing. Enrichments are changes to the zoo habitat that provide animals with opportunities to perform behaviours important for their physiological and psychological well-being (Swaisgood and Shepherdson 2005). For these reasons, environmental enrichment programmes broadening the behavioural repertoire of zoo animals by promoting the performance of a wide array of species-specific behaviours have been found to be a good strategy to improve the animal welfare and husbandry standards in modern zoos (Bayne 1991; Brent 1997; Crockett 1998; Novak *et al.* 1994). However, cautious evaluation should be undertaken when providing new stimuli or programmes to the animals, as some enrichments might be dangerous, frustrating as well as have negative or no effects on the animal behaviour (Hosey *et al.* 2013).

Providing daily environmental enrichments for animals requires intensive efforts to zookeepers and other staff working in the zoo, in terms of time and finding materials. Chimpanzees need to be involved in daily environmental enrichment programmes and zookeepers should prepare several enrichments, including for example manipulative, food-related and sensory stimuli. Enrichments of different typologies should be provided on different times during the day, and the number of enrichments per subjects as well as the frequency of provision per day could vary according to the period of the year. For example, in the breeding season or in other periods of possible social tension or stress, the enrichment programme should be intensified, helping animals to manage their sometimes difficult (social) lives.

2.5.1.1 Beauty is in the eye of the beholder: Artificial vs. natural environmental enrichments

In the last years, enclosure design is becoming increasingly relevant in the field of animal welfare, and naturalistic stimuli-rich enclosures with structural elements such as trees, browse, wooden logs and bundles are widespread in modern zoological gardens. Naturalistic environments are thought on the one side to promote explorative behaviours and providing the animals with the opportunity to hide and seek out privacy. On the other side, they are supposed to enhance visitor perception of the animals and their experience (Stoinski *et al.* 2001; Davey 2005, Ross *et al.* 2012). Although natural enrichments can be effective and appealing for both zoo animals and visitors, the preference and effectiveness of natural versus artificial environmental enrichments can vary from one individual to another (Shepherdson *et al.* 1998; Markowitz 2011; Perdue *et al.* 2012; Young 2013), especially for cognitively complex animals such as chimpanzees. Artificial enrichment devices such as plastic toys, balls, plastic feeders and other devices of different sizes might be valuable stimuli for chimpanzees, leading to the performance of manipulative behaviour and in some cases to the development of new tool-use strategies. For example, chimpanzees have been found to use paper cups or plastic bottles as water storage, filling them with "take-away" water, carried around in the enclosure for subsequent incoming thirst. Previous research investigated the zoo visitors' perception of artificial and natural enrichment devices provided to chimpanzees at Lincoln Park Zoo (Jacobson *et al.* 2017). The study revealed that zoo visitors' perception on chimpanzees' welfare was not affected by the typology of the enrichment device, probably because the exhibit naturalism superseded any effect of the enrichment aesthetic (Jacobson *et al.* 2017). Therefore, environmental enrichment devices seem not to impact dramatically on visitor experience and perception, as reported in previous literature on other zoo animal species (McPhee *et al.* 1998; Kutska 2009), at least in the presence of an appropriate naturalistic enclosure (Jacobson *et al.* 2017). A strategy to enrich chimpanzees and other animals often practiced in zoos, is collecting "waste" material from the zoo employees such as worn clothing and shoes, cartons of all sizes (the bigger, the better!), paper bags, bottles, rolls of paper towels, toilet paper and any kind of safe objects that can be used to contain seeds, straw, fruit, vegetables and other food staff or scents. In some cases, maybe visitors can scarcely appreciate and understand artificial, colourful and flashy enrichment devices, but chimpanzees do! However, caution is needed because zoos also aim to show the species as much as possible as they live in nature and artificial enrichments can be deleterious for this purpose. Moreover, housing species like chimpanzees, which are very closely related to humans in an anthropomorphic setting and offering them objects like cloths, books and magazines bears the risk to make chimpanzees appear like humans, creating laughable clowns and delivering an unappropriated educative message to the public. A possible balance can be reached by providing chimpanzees with artificial "anthropomorphic" enrichments in areas of the enclosure which are not visible to the public or during the hours in which the zoo is closed and no visitors or zoo-staff are present. Zoo animals spend several hours without human presence (e.g., evening and night hours) but they need to be stimulated even in these periods of time. Providing long-lasting manipulative enrichment such as toys, books and magazines could be a good strategy to stimulate and keep chimpanzees busy for quite long time. In the end, it will of course be up to the individual institutions to decide the level of use of artificial enrichment devices related to their institutional policies and standards.

2.5.2 Food-related enrichment

Chimpanzees are mainly frugivores, although they have broad diets that include plant foods (*e.g.;* roots, shoots, leaves, buds, blossoms, seeds and exudates), soil and animal foods, ranging from invertebrate to small or medium-sized mammals (Goodall 1986; Boesch and Boesch-Achermann 2000; Isabirye-Basuta 1989). See also sections 1.5 and 2.2 in these guidelines. In the wild, chimpanzees can spend most of their day feeding and looking for food resources, as the processing time required by the items in their diet can be very long, employing up to 80% of a wild chimpanzee day (Goodall 1986; Doran 1997). Moreover, processing and accessing food items as well as looking for food resources is not only time-consuming for wild chimpanzees but also require high levels of cognitive skill and dexterity (Lambeth and Bloomsmith 1994). However, in controlled environments food resources are easy to find and almost always available, so that these activities are usually less complex and time-consuming. Therefore, food-related environmental enrichments are important for this species and should be intended to prolong the time spent looking for food and to increase the food processing time.

2.5.2.1 Foraging

Foraging enrichment, consisting of small pieces of food such as grapes, raisins, seeds, peanuts, nuts, etc. should be provided daily and food can be scattered around in grassy/vegetated enclosures or could be hidden in hay, straw or even fresh grass. In particular, hay, straw and grass can be used as litter and scattered on the ground or placed in piles or bales. Hay, straw and grass are enriching for chimpanzees as they can use these materials to build comfortable nests (see next paragraph). Freshly cut grass could also be eaten by chimpanzees and could represent a good foraging opportunity if used as litter or in piles, because chimpanzees will look for their favourite grass species and even for insects or other invertebrates hidden inside.

2.5.2.2 Browse

In the wild, chimpanzees also eat various types of leaves, flowers, barks and seeds. For this reason, zoo chimpanzees should regularly be provided with large amounts of fresh browse that will be eaten and used as nest material or for tool manufacture. In Europe, among the most abundant plants that can successfully be used as enrichment for chimpanzees are bamboo, willow, hazel, poplar, birches and to a little extent oaks. Indeed, in large amounts, oak leaves and acorns can be poisonous due to tannic acid and can cause kidney damage and gastroenteritis. In general, the effect that different plants can have on the animals' health can vary greatly from one institution to the other and even from individual to individual and needs therefore to be evaluated. For example, despite oak poisonous potential, in Arnhem Zoo, chimpanzees live underneath many oaks and beech trees and each year feast on the acorns and beechnuts without this having caused any problem since decades. Rather, mature oak twigs have been found to be successful astringent to compensate the purging effect of other food items. Moreover, chimpanzees are known to choose plants based on their medicinal value, as for example they have been found to eat plants helping them to remove parasites from the digestive system or to heal from infections or diseases (Huffman and Wrangham 1994; Huffman *et al.*, 1996). Chimpanzees in the wild have been found to fold and swallow the rough hispid leaves of certain plant species, without chewing, to physically expel intestinal parasites (Huffman 1997; Huffman and Caton 2001). In the field of a study on social learning, Huffman, Spiezio, Sgaravatti and Leca (2010) provided two groups of chimpanzees housed in Parco Natura Viva, an Italian zoological garden, with the nontoxic branches of the Jerusalem artichoke *(Helianthus tuberosus).* The leaves of this plant are closely similar in roughness, shape, and size to those of *Aspillia* and *Aneilema* spp., which are two of the species most often used in leaf swallowing by chimpanzees in East Africa (Huffman *et al.* 1996; Huffman 1997). The study chimpanzees started the leaf-swallowing behaviour soon after the Jerusalem artichoke provision and each group developed different techniques to swallow the leaves without chewing them. Providing zoo chimpanzees with medicinal plants (even species resembling those documented in the wild) could be an opportunity to enhance the animal diet and health with new beneficial food items, promote the performance of new behavioural variants (Huffman *et al.* 2010), endorse the observation of conspecifics as well as individual and social learning. Finally, while improving the welfare of zoo chimpanzees, the provision of plants with medicinal properties could represent a unique opportunity to deepen our knowledge on self-medication in this species. Moreover, even if the zoo subjects involved in the study by Huffman *et al.* (2010) had no intestinal parasites, in other cases this kind of enrichment can be helpful to manage the health state of the animals in a natural and non-invasive way. As several plant species have medicinal properties, providing fresh browse to zoo chimpanzees could benefit not only to their manipulative or cognitive skills but also to their health status: for example, providing fresh willow browse might be particularly beneficial, especially in specific periods of the years, as this plant is known for the analgesic and anti-inflammatory properties (see also 2.2 Feeding).

Caution should be taken as several plants species or even plant parts can be toxic and deleterious for the animal health. Before introducing a new plant species in animal enclosure, the opinion of botanic experts (EAZA horticultural group can be of assistance) and veterinarians needs to be considered.

Providing chimpanzees with adequate foraging and feeding opportunities might represent a source of cognitive and social stimulation, helping to increase the feeding time of the animals and therefore preventing the performance of stress-related behaviour such as stereotypies (Cooper and Jackson, 1996; Celli *et al.* 2003). Moreover, the provision of iced fruits or fruit ice lollies in summer as well as hot drinks in winter (e.g.: herb teas, vegetable soup and chamomile) could help chimpanzees to manage hostile temperature while performing original feeding behaviour such as suckling, licking and drinking.

2.5.3 Manipulative and structural enrichment

Chimpanzees have developed cognitive skills and noticeable food/object processing abilities that deserve to be stimulated even in controlled environment (Fouts 1998; Maple 1979). Together with feeding devices, inanimate objects such as toys and enclosure furniture have been found to positively affect the behaviour and welfare of chimpanzees.

2.5.3.1 Manipulative enrichments

In particular, chimpanzees should be allowed to interact with manipulable objects that can be handled or explored. As mentioned above, such enrichment can lead to anthropomorphism and deliver an inappropriate message to zoo visitors about chimpanzee wild behaviour and appearance. However, manipulable objects can also be wooden blocks, bamboo tubes or other natural devices with low impact on public perception. Items such as plastic or wooden toys (e.g.: balls, Lego, scoops), bottles, cloths, cardboard boxes, magazines or picture books can eventually be provided when animals are not visible to the public visiting the zoo (limiting the option for the chimpanzees of bringing these into public visible areas). Several authors found that in chimpanzees and other primates these enrichment devices reduced the performance of stress-related behaviours, specifically stereotypies and self-directed abnormal behaviours (Brent *et al.* 1989; Kessel and Brent 1998; Shefferly *et al.* 1993; Gaspar 1996). In addition, in a study on zoo chimpanzees by Spiezio *et al.* 2017, manipulative environmental enrichments have been found to promote the performance of species-specific behaviours and reduce abnormal behaviours, specifically stereotypies in hand-reared chimpanzees, characterized by tricky life histories and lacking appropriate social and sexual competence. In particular, the authors collected data on chimpanzees' behaviour before (baseline period) and during a manipulative enrichment programme (ME period), in which chimpanzees were provided with different toys or devices each day such as colour balls, wooden toys and Lego, for a ten-day period. During the ME period, the provision of foraging and food-related enrichment was not interrupted. At the group level, the programme improved the performance of both individual and social behaviours, specifically play. The study group was made of eleven subjects, with six chimpanzees reared by humans. Among the hand-reared chimpanzees, four subjects showed for a little amount of time some abnormal behaviours (rocking and apathy), especially in the baseline period, without manipulative enrichments. In the ME period, the performance of these behaviour decreased and, in some individuals, disappeared completely, suggesting a positive effect of inanimate manipulable objects on the welfare of the hand-reared chimpanzees. Therefore, manipulative enrichment programmes seem to be an important strategy not only to enrich the daily life of zoo chimpanzees in general, but also to help hand-reared individuals to deal with their tricky life history and rearing experience, reducing abnormal behaviour and improving their well-being (Hosey *et al.* 2013; Young 2013; Spiezio *et al.* 2017).

2.5.3.2 Chimpanzee enclosure

The enclosure design is one of the basal and most important forms of enrichment. Chimpanzees' enclosure should contain several furnishings that add complexity to their captive habitat, such as rope, climbing structures, poles and raised platforms stimulating the arboreal life style of the species (Howell *et al.* 1997). In the wild, before sleeping time, chimpanzees are known to build sophisticated and variable nests in the tree canopy, using materials such as leaves, branches and twigs of different plant species (Maple 1979; Suarez and Forter 1995; Howell *et al.* 1997). Nest building seems therefore to represent an important and time-consuming activity for this species that should be stimulated also in controlled environment. Among the best ways to promote nest-building activity in zoo chimpanzees might be the provision of large amounts of hay, straw or fresh grass, clothes, paper, browse and even toilet tissue and kitchen towels. The enclosure of the chimpanzees should have raised platforms or nest structures, in which animals can bring the material found in the enclosure to build their comfortable beds, as they would do in the wild. Moving platforms and dangling ropes might represent natural swings, promoting individual and social play as well as the arboreal locomotion typical of the species, increasing physical activity of the animals. However, ropes of small diameters or frayed dangling ropes should be avoided, as juvenile chimpanzees like putting these items around the neck or on the shoulders while playing and turning around, with possible unpleasant consequences due to unwanted ties (see also section 2.1).

2.5.4 Cognitive enrichments

Chimpanzees are characterized by large brains and multifaceted social lives, leading to complex cognitive abilities and wide behavioural repertoire. Cognitive enrichments, such as problem-solving tasks, puzzle feeders and other stimuli involved in cognitive testing are therefore particularly important for the welfare of this species (Brent and Eichberg 1991; Celli *et al.* 2003). For example, the tube-task, a PVC tube with the inside smeared with peanut butter used in the study of handedness in primates, has been found to decrease inactivity promoting tool use and manipulation (Celli *et al.* 2003). Cognitive enrichments have also been found to stimulate the complicate social life of chimpanzees, promoting important and positive social interactions such as social play (Clark and Smith 2013).

In the wild, several tool-use behaviours have been documented in this species (Sanz and Morgan 2007), such as termite-fishing, intended as inserting a twig into a termite mound and extracting the termites that attack and cling to the tool (Lonsdorf 2005) or nut-cracking with stone-hammer and anvils (Inoue-Nakamura and Matsuzawa 1997; Matsuzawa 2011). Although different populations of chimpanzees use diverse tools or techniques to solve problems, this practice is clearly an important component of their behavioural repertoire that need to be stimulated also in controlled environment. For example, providing cognitively complex tasks such as artificial termite mounds filled with different kind of food (not necessarily insects) and twig-type tools to zoo chimpanzees might keep the animals engaged in food research for a long time, enhancing their mental and physical health and preventing boredom and stress-related behaviour (Paquette and Prescott 1988; Celli *et al.* 2003; Yamanashi and Hayashi 2011). Chimpanzees can also select tools based on their physical properties required for the task (Seed *et al.* 2012) and can modify or combine objects to make appropriate tools to solve a task (Bania *et al.* 2009). Variable fillings of the artificial termite mounds might promote different tool-use behaviour: chimpanzees can use and prepare stick to fish for dense rewards such as yogurt or honey, whereas they can use straws to suckle juice or other liquid rewards. Promoting natural behaviour such as termite-fishing might provide chimpanzees with a stimulating and rewarding activity and could be appreciated also by the visitors. Moreover, promoting tool-use behaviour might be an opportunity for researchers to study this skill in chimpanzees in more controlled environments than in the field. However, caution should be given when providing chimpanzees with certain tools, specifically very large ones (e.g.: trunks or perches), as they can also be used to sabotage the enclosure leading to dangerous animal escapes.

Examples of different types of environmental enrichment can be found in *Table 14*.

Table 14. Examples of environmental enrichment for chimpanzees

Enrichment	**Type**	**Picture**	**Source**
Fabrics	Manipulative enrichment Chimpanzees can use textiles and fabrics to build nests, to warm up and to play. Fabrics can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Jute sack	Manipulative/feeding Jute sacks can be used as cloths to build nests, to hide or to play. They can also be filled with hay or straw to hide small treats, fruits and vegetables. Jute is natural and has a relatively low visual impact for visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Fresh grass	Feeding Chimpanzees can feed on freshy cut grass by selecting the favourite plant species. They can also use grass to build suitable nests or comfortable pillows.		Parco Natura Viva – Garda Zoological Park, Italy
Clothes	Manipulative Chimpanzees can use clothes to play, build nests, warm up or try to wear them. Anthropomorphism risk is high with clothes. Good in winter, when the park is closed.		Parco Natura Viva – Garda Zoological Park, Italy

Cups	Manipulative/feeding Cups of different materials can be used to provide food or liquids. Food can be placed in the cup or hidden in hay or straw. Plastic and colourful cups can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Boxes	Manipulative/feeding Boxes of different size and typology can be used to provide food hidden in hay or straw. Boxes can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Wooden/or Lego blocks	Manipulative/sensory Simple wooden or Lego blocks can be used to promote playing or manipulative behaviours in chimpanzees. Wood can be impregnated with odours such as spices and parfums and can have relatively low visual impact.		Parco Natura Viva – Garda Zoological Park, Italy
Plastic balls	Manipulative Colourful balls can be used to promote chimpanzees' play behaviour and manipulation. Drilled balls filled with small pieces of food can be used as feeder. Balls can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Artificial termite mounds	Cognitive Artificial termite mounds can be filled with dense food (e.g., honey) or liquids (e.g., juice, herb tea) that can be reached by chimpanzees using plant twigs or straws as tools.		Parco Natura Viva – Garda Zoological Park, Italy

Hats	Manipulative Chimpanzees can use hats to play, build nests or try to wear them. Hats can have high visual impact for zoo visitors and anthropomorphism risk is high.		Parco Natura Viva – Garda Zoological Park, Italy
Bamboo internodes	Manipulative/cognitive/feeding Juvenile bamboo trunks are easy to cut whereas lignified ones are long-lasting. Bamboo internodes can be used to hide treats (that can be put or smeared inside the trunk). They have a low impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Paper bags	Manipulative/feeding Bags of different size and typology can be used to provide treats hidden in hay or straw. They can also be used to play or build nests. Bags can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy
Artificial feeder	Manipulative/feeding Plastic containers of different size and typology can be used to provide treats hidden in hay or straw. They can hang somewhere.		Parco Natura Viva – Garda Zoological Park, Italy
Carnival trumpets	Manipulative/sensory Trumpets can be used to promote play and manipulation. Any chimpanzees could also find out the noisy properties of the trumpets and spread the new behaviour. Trumpets can have high visual impact for zoo visitors.		Parco Natura Viva – Garda Zoological Park, Italy

Pinecones	Manipulative/feeding Pinecones can be provided in their natural form or they can be filled/smeared with treats. Cones can have low visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/
Tennis balls	Manipulative/cognitive Tennis balls can be filled with treats, representing a valuable feeder for chimpanzees. They can have high visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/
Foraging board	Cognitive Foraging boards can be filled with raising, seeds, honey or other treats that chimpanzees can reach using tools such as twigs. They can have low visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/
Plastic bottles	Manipulative/feeding Plastic bottles can be used to hide food treats or liquids. Chimpanzees can use empty bottles to store water and carry it in their nests. They can have high visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/
Sugarcane	Feeding Sugarcane can be cut, frozen and thrown across the enclosure to promote chimpanzees' foraging behaviour and food-processing skill. Sugarcane is natural and has low visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/
Piñatas	Manipulative/feeding Container generally made of paper, pottery or cloth that can be filled with treats. They can have high visual impact for visitors.		https://www.savethechimps.org/chimp-life/enrichment/

Painting materials	Cognitive/sensory In some cases, chimpanzees can learn to use paintbrushes and colours to draw on papers or different substrates. Anthropomorphism risk is very high and can be deleterious for “wilderness” of parent-reared chimpanzees.		https://www.savethechimps.org/chimp-life/enrichment/
Ice lolly, large	Feeding Frozen juice, fruits or water with treats inside can be enriching and refreshing for zoo chimpanzees especially in summer or hot periods of the year.		Project Chimps https://projectchimps.org/tag/blue-ridge-mountains/
Ice lolly, small	Feeding Frozen juice, fruits or water with treats inside can be enriching and refreshing for zoo chimpanzees especially in summer or hot periods of the year.		Parco Natura Viva – Garda Zoological Park, Italy
Hay feeder puzzle	Feeding/manipulative Horse hay feeder bags can be re-purposed to make a chimpanzee enrichment puzzle by hiding treats in the hay.		Chimpanzee Sanctuary Northwest https://chimpsnw.org/enrichment/hay-feeder-puzzle/
Puzzle feeder	Cognitive Reaching for treats in puzzle feeders can be time-consuming and important for the psychological well-being of chimpanzees.		Zoo Bratislava

2.6 Handling

Lars Versteege

2.6.1 Individual identification and sexing.

The most important issue dealing with individual identification is off course the ability of the keepers to recognise each animal, preferably from greater distance as well. Each keeper working with chimpanzees should have this capacity and furthermore, each keeper working with the chimpanzees should know the individual character of each chimpanzee. After a birth, the mother should be identified straight away, as well as the sex of the new-born. Usually, the sex of the new-born can be seen already on short term, depending on how protective the mother is. Determining who the father of the young is might be more complex in a natural chimpanzee breeding group, containing multiple males. To be certain of this, a paternal test should be carried out in an appropriate laboratory. This means that DNA should be collected of each of the potential fathers, of the mother and of the young. Luckily this can nowadays already be done through hair sack follicles. If this proves too difficult then it is recommended to collect DNA of each animal whenever the possibility arises, i.e., when an animal is sedated for veterinary reasons. This also gives the opportunity to administer or check the number of a micro transponder. Each chimpanzee should have a micro transponder implanted. Chimpanzees are listed on App. 1 of CITES and for that reason alone individual identifiers are obligatory. Without it an animal can never be transported to another institution. A commonly used microchip is the ISO accredited transponder. Older TROVAN transponders should work as well, since most of the current readers can read out TROVAN chips as well.

Administering a microchip is a technique which should not be underestimated. Best practise is to use one hand for the needle to go into the animal and one hand to control the skin of the animal, especially when taking out the needle again. Too often the micro transponder has been lost outside the body when taking out the needle. If you control the skin of the animal, the chance that a micro transponder sticks to the needle when taken out is minimised.

A neonate should not be specifically sedated for DNA collection, micro transponder administering etc. Fortunately, sedation is not always necessary to collect a sample of hairs with roots for DNA extraction. In case that sedation is required for veterinary reasons, it is advised to also collect a blood sample or a sample of at least 10 hairs with roots for subspecies determination, for storage in the EAZA Biobank for future research or for paternity determination. It is crucial for the EEP to accurately establish the relatedness within the programme and avoid having to include all potential sires. This will also avoid complications when applying for a CITES permit.

2.6.2 General handling

Direct contact between keepers and chimpanzees cannot be avoided, but caution should always be taken. Chimpanzees are immensely strong animals and are known for their ability to carry out serious aggression without direct prior inducement of provocation. Many examples of keeper injuries and even deaths have been registered throughout the years. Also, in regard to zoonosis direct contact should be avoided as much as possible.

Exhibits should be designed in such a way that keepers can work in protected contact with the animals. Especially the barriers, i.e., vertical bars should be designed to avoid chimpanzees reaching out too far and grabbing keepers. This is one of the reasons why mesh (40x40x5 mm) is preferred and bars are not recommended (see chapter 2.1.1.4. Fences).

It is important to have individual daily management. Chimpanzees easily adapt to individual training and by taking time for each individual, assurance can be given that they receive their daily care. For example, one can choose to feed particular important food items during these individual sessions which then also enables the keepers to administer medicines/contraceptives in the food or drink when needed.

2.6.3 Capture/restraint and immobilisation

Many different ways of catching chimpanzees are discussed in literature (AZA Ape TAG 2010. Chimpanzee (*Pan troglodytes*) Care Manual), and each has their advantage or disadvantage. From catching/restraining cages, chutes etc. to full anaesthesia. It totally depends on your facility and also on the opportunities you have to train the animals (Schapiro *et al.* 2005, Lambeth *et al.* 2006, Perlman *et al.* 2012). For more info on capture, restraint and immobilization (see chapter 2.8 Chimpanzee Veterinary Aspects).

2.6.4 Transportation

Great care must be given to crates being strong enough to transport chimpanzees. Crates with complete inside metal or concrete enforced plate work, frames, bars are recommended above only wood. Crates should have doors on both sides to be able to use them as corridor between cages in order to train the animal (see also chapter 2.1 Enclosure (accommodations) for facilitating crate training). Next to closed or semi-closed doors, mesh or bar doors should be used. These primary doors (mesh/steel bars) are the most important and should be constructed into a sliding device which does not allow the chimpanzee to get a grip on the doors. Too many examples are available of chimpanzees blocking sliding doors with their strength or pulling doors out of their rails or gliding system.

In general, these kinds of crates tend to be made very heavy but it is possible to make good chimpanzee crates which weigh around 100kg. Measurements which could be recommended are 132cm long, 70cm wide and 101cm high outside and internal measurements of 116x54x86. For transporting a female together with a young (<6 yrs.), a wider crate should be used.

2.6.5 Safety

Safety is a primary concern when building ape enclosures (see chapter 2.1 enclosure (accommodations)).

Safety concerns should also be included in the daily routines of staff working with chimpanzees. The condition of the barriers and locks should be checked with great care. The enclosures should be checked daily to the possible presence of objects and materials that the chimpanzees might use to damage or pass through the barriers. Stones can be used to break glass barriers, sticks or branches can be used as ladders to climb surrounding walls or even to damage the mesh.

Clear protocols or working instructions are essential. Essential parts of a safety protocol are:

- Handling chimpanzees alone/multiple keepers
- Decisions regarding shifting animals
- Protocol for making sure all animals are accounted for before opening doors
- When working with multiple keepers, a communication protocol about who is responsible for what. There cannot be any misunderstanding between keepers when dealing with chimpanzees.
- Double-checking which doors are locked and which are not before and after handling any door.
- A clear protocol on how to handle a case of an escape.
- Clear guidelines on how to handle a case of injuries to staff and/or visitors.

2.7 Introduction

Charlotte Macdonald, Jana Pluhackova, Frands Carlsen, Tom de Jongh

Introductions of chimpanzees to either unfamiliar chimpanzees or familiar chimpanzees from whom they have been separated need to be managed carefully due to the potential volatile nature of this territorial species. A lot of factors must be considered regarding the current or resident group; the new incoming individuals or group; the facility they will be introduced to; and the experience of the team managing the introductions. Introductions pertaining to transfers from other zoos must be planned and discussion with the EEP Coordinator and Introduction Advisors should start as far ahead of an introduction as possible. This allows time for all possibilities to be fully considered including whether the facility requires modification works.

There is a paucity of data available on factors affecting introduction success, or on the process involved in introducing chimpanzees and only a limited number of studies have been published (Alford *et al.* 1995; Baker and Aureli, 2000; Brent *et al.* 1997; Brent 2001; Herrelko *et al.* 2012; Herrelko *et al.* 2015; McDonald 1994; Schel *et al.* 2013; Seres *et al.* 2001; Stevens and Van Elsacker 2005) but the number of introductions being carried out are increasing as more is learned about the EEP population and the long-term management plan is implemented. Zoos that are doing introductions are therefore encouraged to keep detailed records about the process and the individuals, both during and after the integration.

2.7.1 Advance planning stage

After the decision has been made which new individual to introduce into which group, several factors must be considered prior to introduction. These include a broad range of social and physical factors about the resident group, the new individuals and the facilities.

2.7.1.1 Group factors

Who is being introduced to whom? Is it a small group (pair, trio) to a group or an individual to a group or individual?

- Current group structures: How many individuals are in the group? Who is dominant, both male and female? What coalitions and alliances exist within the group? Is the hierarchy stable or are there challenges going on? If stable, how long has the group been stable for? Are there individuals in the group that are likely to take an opportunity to challenge the current hierarchy?

- Past group structures: How has the hierarchy of the group changed over time? Are there ex-dominant animals in the group who are now lower in status and how do they interact with other members of the group? To whom are they allied?

2.7.1.2 Individual factors

- Age: How old are they? What life stage are they at (infant, weaned juvenile, independent adolescent, adult, geriatric)? Is the introduction considered of an infant or weaned juvenile together with the mother?

- Sex and reproductive status: Male or female? Are the males fully intact, castrated, vasectomised, on chemical contraception? Are the females reproductively active, in oestrus or not at the specific point of introduction, sterilised or on contraception and what type? If on contraception, do they still have sexual swellings? Usually, it is not recommended to introduce females when they are in season, but this also depends much on the individual situation. The analysis of the studbook data suggests that younger females have a better likelihood of a successful introduction (Coslovsky and Baumeyer 2018, unpublished). In the wild, chimpanzee females typically migrate to other groups upon reaching maturity (Nishida and Kawanaka 1972; Pusey 1979; Boesch and Boesch Achermann 2000). Females in human care may however also be transferred to new groups later in life as this also sometimes happens in nature. Furthermore, comparing to the natural situation, it makes sense to introduce single females to unrelated groups, unless the social dynamics of the resident group are such that the introductee would benefit from having social support in the form of a female friend. The males in the new group will ensure that newcomers can integrate and there is no preference to send related females to new groups. This might even have negative effects, if females form bonds among each other that are too strong. In addition, the difference between introducing single females and small groups of females does not change the success of these introductions in a meaningful way (Coslovsky and Baumeyer 2018, unpublished). The possibility to transfer single or multiple females should not influence decisions for population management purposes.

- Health status: Does the individual have any acute, chronic or recurring health concerns? Are they on medications and are they regularly compliant at taking it?

- Social status: What rank does the individual hold in their current situation (prior to introduction)?

- Relationships with other group members: who is this individual related to? Who do they have strong bonds with?

- Rearing history: was the individual hand-reared, mother/foster-reared? If hand-reared what degree of contact did the individual have with other chimpanzees and at what age, when was the individual fully integrated into a group, is the individual still cared for by the keepers who did the hand-rearing and what is their relationship like now? Brent (2001) found that rearing history and sex has a significant impact on the outcome of chimpanzee introductions with non-parent-reared males being more difficult to integrate than other males and females.

- Personality: is the individual open, boisterous, nervous, friendly?

- Social experience: Has the individual lived alone? In a small group (pair or trio)? In a large group? In a single-male group? In a multi-male, multi-female group?

- Management history: are there any aspects of this individual's management that should be highlighted such as aggressive to keepers, is an alpha but physically bullies the others?

2.7.1.3 Facility

Chimpanzee facilities vary greatly across zoos, but several facility-based factors may contribute to a positive outcome for introductions. A study by Herrelko *et al.* (2015) showed that the complexity of space in the overall habitat, having numerous separate but connected "rooms", was more important than total space available to chimpanzees during introductions possibly because it offered the chimpanzees choice to exhibit preferences in terms of their physical location and by association therefore, choice about who to be in proximity with.

As a minimum the facility must have:

- Two areas where chimpanzees can be temporarily housed for months at a time; three areas are preferable as it provides more flexibility;

- Access to a safe outdoor area, being aware that water-moated enclosures present a particular challenge for naïve individuals when they are under social pressure;

- A series of off-show management cages, minimum of three areas in a row, where chimpanzees can have safe contact with each other through mesh, prior to full physical contact, with a slide in-between each of the areas that can be secured into a semi-open position at a gap of 12cm (Seres *et al.* 2001). The EEP suggests having each of these cages with an area of 7.5 m^2 or more and with the narrowest side on the service corridor and not less than 2.4 m^2. In each of the walls between those cages should preferably be two sliding doors, as far away from each other as possible. This facilitates safe circulation between the cages and avoids dead ends. Even despite a careful introduction procedure, the risk of conflicts through the mesh can never be completely eliminated. For that reason, we suggest not to use mesh with a larger size then 4 x 4 cm. Bars are not recommended (see Chapter 2.1). Any gaps between the fence and the surrounding structures (walls, doors, floor, ceiling) should not be wider than 2 cm. Keepers must be able to see this entire area clearly to monitor the introduction and should be able to intervene here if necessary.

  These cages will then also be suitable and available for other occasions in which individuals must be temporarily separated from the group. The number of those cages for those additional purposes may have to be raised, depending on the group size (see Chapter 2.1).

- It should also be possible for the animals to choose to be in the sight of the other, or not, so a retreat space that includes at least a partial solid wall or other visual barrier is important.

- This area should be completely out of view of the chimpanzees that will not be involved in the specific introduction session – it may be just two chimpanzees involved in this particular session if using a dyadic introduction approach. There should also be as much distance as possible between the chosen introductees and the non-introductees, or rest of the group, to limit any possible interference or distraction.

- Each of the areas must be connected by at least one, but preferably two slides, (see 2.1.1.10 Animal doors) one of which must be able to be secured in a partially open position at a gap of 12cm. It must be possible to have a mechanism on this slide such that the chimpanzees cannot force the door open further as it is being operated, so there needs to be some sort of mechanical limitation on the door; or if this is not possible the door must be opened to the 12cm position and secured before the chimpanzees have access to it. Two slides in each connecting wall will prevent a dominant chimpanzee from controlling the doors and also reduces the risk of a chimpanzee being cornered as the chimps can move around in circles and have potential escape routes.

- It should be possible for the chimpanzees to approach the barrier at the front of the areas, just next to the mesh wall separating them.

- Limiting the noise that chimpanzees can make by banging on the sliding doors and fences is of particular value in the introduction area (see 2.1.4.2.5 Sound).

- Keepers must have tools available should they need to intervene in a severe, life-threatening situation. Intervention is not recommended unless a chimpanzee's life is in danger. These tools can include hoses, water pistols, fire extinguishers.

- The area must have direct connections to the outdoor or other indoor enclosures so that the newly introduced chimpanzees can be released into an area separate to the main group if necessary.

Prior to starting the introduction all newly transferred chimpanzees must have the opportunity to explore and spend time in all areas of both the indoor and outdoor enclosures. This is to ensure they are familiar with the layout and potential retreat routes to get away from other chimpanzees if they need to. If the outdoor area is water-moated and the new chimpanzees are naïve to this it cannot be assumed that they recognise the risk it presents, even after brief familiarisation. Chimpanzees that are not habituated to water moats will still try to use them as a potential retreat route if they are being chased or harassed by other chimpanzees. The risk of water moated enclosures must not be underestimated at times of social tension so in existing facilities critical attention must be paid to the design of the moat (water moats are not recommended (see Chapter 2.1 Enclosure)). Other surrounding barriers and safety routes for chimpanzees also deserve critical attention.

When there is no alternative option but to introduce chimpanzees in an enclosure with a water moat a very calm and prolonged process must be put in place. All initial introductions must be done as explained, in the indoor enclosure where there is no access to the water moat.

Separate to these introductions, the new chimpanzee or chimpanzees must be given access to the outdoor enclosure on their own, without pressure from the resident group. They must be given many days to explore their new enclosure and identify routes of access and travel, so that they can safely escape from any social challenges if required when they are integrated with their new group. If these new chimpanzees have never had access to a water moat previously, they will not fully understand the risk it represents to them. It is recommended that a temporary electric fence is placed on the land, at the boundary of the water moat and that this fence is obvious to the new chimpanzees, to enable them to learn to avoid this area. After some time, this fence can be removed and the main moat and fence combination can be made available to the new chimpanzees, in the absence of the resident group. It is critical that they are given time to get used to the water and its exact location without any additional pressures. It must be stressed that even with a prolonged process of introduction to the moat it still represents a significant risk to chimpanzees particularly during times of social tension.

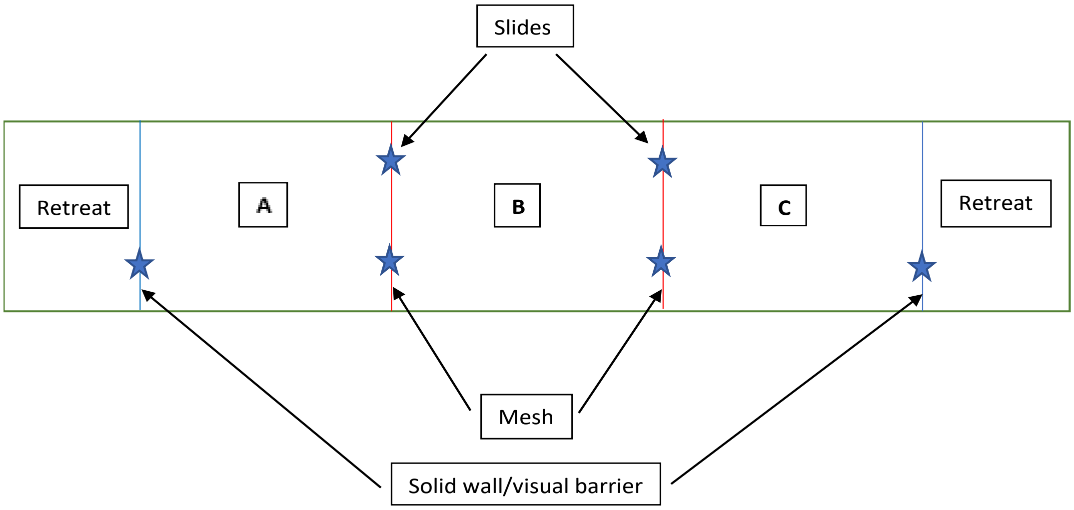


Figure 39: Recommended layout of introduction area (Figure Charlotte Macdonald).

2.7.2 Introduction stage

Every individual must be very carefully selected for an introduction bout, based on behavioural compatibility. The keepers who know the chimpanzees involved are in the best position to recommend the individuals and this can be discussed with the EEP Coordinators and Introduction Advisors. This selection is one of the most important elements that will determine a successful introduction and is why the Introduction Advisors will request behaviour and personality information on every chimpanzee to be involved. Where large numbers of chimpanzees are involved, consideration must also be given to who remains in the resident group and the social stability of both the “old” group and the “new” group must be considered in a process that could take some months to finish.

The actual introduction must be carried out in an off-show area with the ability for keepers to see clearly what is happening and intervene if necessary. The space must be safe for the chimpanzees to express natural behaviour, including some agonistic behaviour, if they choose to do so. It is highly recommended that initial introductions take place in the management area of the facility with cages in an ABC configuration and a minimum of three in a row (see *Fig 39*). This will allow visual introductions to occur across an empty neutral space, then first physical contact to be established in a protected situation through mesh, before full physical contact is established.

2.7.2.1 Dyadic introductions

Much success has been achieved using dyadic introductions (Seres *et al.* 2001; Stevens and Van Elsacker 2005; McDonald 1994), ensuring that every individual has an opportunity to safely meet every unfamiliar individual on a 1:1 basis prior to full group integrations. This is done for relatively short periods of time (30-90 minutes) and depending on the number of chimpanzees involved can quickly add up to large numbers of dyadic sessions. These sessions are essential for the chimpanzees to gain information about each other and for the keepers to gain an invaluable insight into the potential different reactions and relationships that might develop during full group integration. One study carried out at a research facility (Brent *et al.* 1997) found that the frequency of aggression in male-male introductions was higher when they were integrated using the dyadic method than if the individual newcomer was introduced to the whole group. However, the conditions in this study were very different to those in European zoos so it is not consistent with most other sources of relevant information which support the dyadic approach techniques.

Where facilities allow, dyadic introductions can then be followed by the formation of a new, 3rd group, centred around the incoming individuals if only one or two chimpanzees are being introduced or, where two large groups of chimpanzees are being merged, by selecting individuals from each of the original groups based on the knowledge gleaned during the dyadic introductions and gradually increasing this group size. Chimpanzees can be added to this group gradually resulting in the formation of the final integrated group.

Dyadic introduction process:

- Individuals to be introduced should initially be brought into areas A and C, ensuring the slides into area B are securely locked. This will allow visual and auditory contact across an empty space. It is likely the chimpanzees will be excited or agitated at this point, but that response should reduce quickly, allowing for a good opportunity for the chimpanzees to safely interact with each other.

- When they are calm, one of them should be given access to area B. This will allow protected physical contact through the mesh. Do not open the slide when they are excited or agitated. Keepers should be looking for positive, friendly behaviours including panting, approaching for play, grooming through the mesh.

- As soon as they are calm in this AB situation the slide between them should be opened up to 12cm and secured in this position (see *Fig.40*).

Figure 40: Protected physical contact through a gap under the sliding door (Photo T. de Jongh)

(See also Appendix III, presentation on the function and significance of "GAP" settings during introductions by M. Seres.)

This allows physical contact by allowing the chimpanzees to fit their arms through without full physical integration thus still providing an opportunity for safety. Chimpanzees can use this stage to really gauge the other's intentions and keepers can learn a lot from this stage. If the chimpanzee's intentions are positive playing and grooming behaviour should be evident, accompanied by panting or grunting; if their intentions are not positive aggression will be seen including pulling, scratching and biting accompanied by screaming and probable fear grinning. It is also possible the chimpanzees will not interact with each other at all in this situation and then it is recommended to repeat this trial later.

- If the 12cm stage is positive or if there is no interaction despite at least two trials, then the slide can be opened fully to allow full contact. It is likely the chimpanzees will be very excited and follow the species-typical behaviour pattern described by Baker and Aureli (2000). They have shown that chimpanzees exhibit specific behaviours in a specific order during full contact introductions. This behaviour pattern starts with agonistic behaviours (including bared-teeth scream, bite, bluff display, crouch flight) followed by brief touching, followed by allogrooming. It is believed the brief touching acts as a way to assess the other's potential for aggression but is also a friendly gesture that allows for quick retreat if necessary. Furthermore, it builds trust and acts as a prelude to allogrooming. This species-typical pattern of three behaviours was seen in dyadic introductions involving male-male and male-female animals, and also occurred in dyads that were previously familiar. Brent (1997) noted that very submissive behaviour from one individual was often linked to an unsuccessful introduction, so this further supports the option of taking more time with introductions to allow friendship and confidence to develop between the chimpanzees, particularly if one of the individuals is very submissive.

- Once all individuals have met each other in a dyadic situation, smaller sub-groups can be formed. The order of individuals in this process will be determined by the knowledge gleaned in the dyadic introduction phase. This sub-group will then grow by the gradual introduction of more than one individual at a time. Exact timing will depend on the group but the addition of two individuals every 1-3 days could be used as a general guide providing behaviour is generally positive. If aggression is seen, it can be slowed down and in some circumstances such as in a large group a longer time period may work better as it will allow bonds of friendship to develop.

- If chimpanzees ignore each other in the AB configuration a small amount of food can be scattered near the mesh between the cage A and B. This will encourage the chimpanzees to come into proximity with each other in a safe environment. Once the food has been scattered the keeper should step back and not intervene any further but observe from a distance.

2.7.2.2 Non-dyadic introductions

There will be situations where it is not possible to do dyadic introductions with all individuals, perhaps because of the facilities available, and thus consideration must be given to first introductions involving more than two individuals at a time. As a general rule the process is similar to the dyadic process but involves more chimpanzees at each point. This, of course, increases the risk in the integration process.

- Animals to be introduced should initially be brought into areas A and C, ensuring the slides into area B are securely locked. This will allow visual and auditory contact across an empty space. It is likely the chimpanzees will be excited or agitated at this point but that should reduce within minutes.

- When they are calm, one cohort should be given access to area B. This will allow protected physical contact through the mesh. Do not open the slide when they are excited or agitated. Keepers should be looking for positive, friendly behaviours including grooming through the mesh.

- As soon as they are calm in this AB situation the slide between them should be opened to 12cm and secured in this position. This allows physical contact by allowing the chimpanzees to fit their arms through without full physical integration thus still provides an opportunity for safety. Chimpanzees can use this stage to really gauge the other's intentions and keepers can learn a lot from this stage.

- If the 12cm stage is positive, then the slide can be opened fully to allow full contact. It is likely the chimpanzees will be very excited, but it is not known if they will follow the species-typical behaviour pattern described by Baker and Aureli (2000) when not in a dyadic situation.

- As much space as safely possible should be provided to the chimpanzees, with no blind corners or dead ends. Keepers must monitor and observe the situation closely, without interfering (i.e., no shouting, loud noises or interacting with the chimpanzees at all. Depending on the space available multiple keepers may be required to be able to observe all areas but the number of people present should be kept to the minimum necessary. It is helpful to record the event on video, as often in the heat of the moment a fast interaction or behaviour can me missed so the video allows playback and further analysis after the event. The specification of the camera needs to be considered to ensure it is wide enough to capture the whole event but close enough to see the reactions and identities of the chimpanzees.

- The initial small group can then be grown by the gradual introduction of more small cohorts, following the same steps. Exact timing will depend on the groups but the addition of more individuals every week could be used as a general guide, providing behaviour is generally positive. If aggression is seen, the process should be slowed down but not stopped, a certain level of aggression can be normal and if it is followed by reconciliation that is a positive sign, so the chimpanzees must have time to allow them to reconcile after aggression has occurred.

- If chimpanzees ignore each other in the AB configuration a small amount of food can be scattered near the mesh between the cage A and B. This will encourage the chimpanzees to come into proximity with each other in a safe environment. Once the food has been scattered the keeper should step back and not intervene any further but observe from a distance. If they continue to ignore each other despite repeated attempts it is worth considering the addition of a socially skilled chimpanzee who may mediate between the two, if such a chimpanzee is present in the group.

2.7.2.3 Introducing familiar chimpanzees

There are rare occasions when a chimpanzee might have to be separated from its group with immediate effect, for example for veterinary care, and then a subsequent, unexpected introduction has to happen between the chimpanzee and its group members. The critical points of consideration in this circumstance are the length of time the individual has been separated; whether the animal has had any contact with its group, for example through the mesh, or whether it was completely isolated; its physical health and ability to move around (if it has been separated for veterinary care); its sex; and its rank in the group hierarchy. It is not recommended to separate chimpanzees from their group unless unavoidable.

- If the chimpanzee has been separated for less than 48 hours it is advised to follow the general process as outlined above with the ABC configuration but to move this process quickly, most likely introducing all chimpanzees back together within one day using the non-dyadic approach.

- If the chimpanzee has been separated for more than 48 hours it is advised to follow the general process as outlined above with the ABC configuration, using a non-dyadic approach and possibly moving as fast as introducing new chimpanzees every day until the group is back together.

- The behaviour of the individuals will dictate the speed at which the process can be managed.

- If the isolated animal is a female, it is highly likely the dominant male will be physically aggressive to her when she returns to the group so it must be ensured that she has safety routes available if she needs them. This behaviour from the male is simply him reinforcing his status on her and is usually minor, constituting beating rather than biting.

- If the isolated animal is a male, and particularly if he has been away from the group for more than 48 hours, it is possible that other males have started to reposition themselves within the male hierarchy, so there is a chance there will be some hierarchical aggression over the days following his return whilst the males settle into their various positions again. Alford *et al.* (1995) have shown that most serious wounding occurred when adult males were reintroduced to former group mates following lengthy separations of over 12 weeks.

- In all circumstances chimpanzees must not be isolated from their group longer than necessary as the longer they are isolated the more difficult it is to reintroduce them.

2.7.3 Managing conflict during introductions

When introducing chimpanzees, it is likely there will be some agonistic behaviour during the process. The exact introduction process is planned to mitigate that aggression, reduce conflict and build tolerance. The type and intensity of agonistic behaviour will vary depending on the individuals and circumstances in each introduction, but typically male-male introductions involve more agonistic behaviour than either male-female or female-female introductions and this is supported by a study by Alford *et al.* (1995) which showed that most serious wounding occurred during male-male introductions when there were large differences in the age and social experience of the chimpanzees, but there are exceptions to every rule and powerful female-female and female-male coalitions can show significant aggression towards newcomers. Agnostic behaviour includes, but is not limited to, bluff display, screaming, hitting, biting and chasing. It is critical that keepers are experienced in interpreting natural chimpanzee behaviour in order to determine when subtle aggression is occurring and how to manage it before it escalates into overt aggression.

Agonistic behaviours are part of the repertoire that chimpanzees use to establish and maintain their place in the social hierarchy and animals will fight to protect their status. In an introduction situation a new hierarchy needs to be established to take account of the newcomers. Whilst every effort should be made to mitigate aggressive behaviours it is recommended that aggression is permitted when it occurs and the chimpanzees are allowed to display this side of their natural behaviour, with keepers only intervening in bouts of significant aggression that are likely to represent a risk to life. It is not uncommon for chimpanzees to sustain wounds as part of their natural behaviour and often these resolve without veterinary intervention. If keepers do need to intervene in an extreme situation, tools such as water pistols and fire extinguishers can be used.

It is critical that chimpanzees have opportunity to reconcile following an aggressive interaction and keepers should monitor the chimpanzees to observe when this happens. If it does not happen then the dispute remains unresolved and more aggression is likely to occur, but this must occur unless it represents a risk to life.

2.7.4 Summary

Whilst this section outlines a stepwise process for introductions, it is acknowledged that each stage in the process can only be planned based on the judgement of the measure of success of the previous step. It is highly recommended that anyone due to manage a chimpanzee introduction contact the EEP Coordinator and the Introduction Advisors in advance of the integration.

2.8 Chimpanzee veterinary aspects

Hanspeter Steinmetz, Sharon Redrobe, Romain Potier

2.8.1 General considerations for health & welfare of chimpanzees

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

All EEP-approved chimpanzee collections should have a preventative health program implemented by the responsible veterinarian.

The program should include:

- good record keeping practice
- bi-annual faecal testing for pathogenic bacteria and parasites
- review of body conditions, exercise and diets
- regular evaluation of a potential vaccination program
- storage of serum, tissue samples and genetic material
- testing of most common diseases when opportunity arises
- comprehensive post-mortem examination
- a preventative health program for employees working with chimpanzees

Veterinary services are a vital component of excellent animal care practices. The veterinarian should make regular inspections of the animal collection. Animal record keeping is an important element of animal care and ensures that information about individual animals and their treatment is always available.

2.8.2 Transfer examination and diagnostic testing recommendations

The transfers of chimpanzees between zoos occur as a result of EEP recommendations. These transfers should be done according to European and country specific legislation and with specific examination and diagnostic testing for determining the health of the chimpanzees. If an immobilization is required, it is a chance to collect as much information as possible.

2.8.2.1 Minimal pre-shipment / quarantine database for chimpanzees

- Identification: age, sex, origin, studbook #, Species360 #, transponder

- Anamnesis: Previous medical history (including previous health screens, medical problems, diagnostic test results, treatments, contraception, anaesthetic data and diet information)

- Complete physical examination (ophthalmic, optic, dental, lymphatic, cardiovascular, respiratory, abdominal palpation, musculoskeletal, urogenital, neurologic)

- Body weight. Morphometric data if requested by the EEP

- Faecal analysis:

    - Negative parasite screen – direct, flotation and sedimentation of faeces for detection of endoparasites

    - Negative faecal culture for enteric pathogens (*Salmonella* sp., *Shigella* sp., *Campylobacter* sp., pathogenic *E. coli*, *Yersinia*)

- Mycobacterial testing: e.g., comparative intradermal skin test, lavage-gastric, -tracheal, -bronchial, TB rapid test and/or Primagam (depends on availability). Low sensitivity and/or low specificity make TB testing a challenge. A combination of different tests is recommended depending on availability.

- Blood collection for

    - Haematology, full blood cell count, blood typing as needed

    - Serum biochemistry panel: including cholesterol, triglycerides, HDL, LDL and VLDL, and protein electrophoresis. Consider adding baseline thyroid testing for adults > 15 years (free and total T3, free and total T4 and TSH)

    - C reactive protein as needed

    - Cardiac markers for geriatrics (>25y) such as Troponine and BNP

    - Possible serologic testing, depending on current local epidemiological situation of institution: Simian Immunodeficiency Virus (SIV), Simian Foamy Virus (SFV) Cytomegalovirus (CMV), Respiratory Syncytial Virus (RSV), Simian Adenovirus (SA-8), Measles, Human Varicella Zoster (HVZ), Epstein Barr Virus (EBV), Parainfluenza I, II and III, Influenza A and B, Hepatitis A, B and C, *Herpes simplex*, *Echinococcus*

    - Contact Veterinary Advisor regarding testing or positive individuals before testing. If screened for other diseases, please decide before what to do when tests are positive.

    - Serum banking min. 2ml and genetic material as recommended

- Thoracic radiographs in upright position

- Revise immunization

2.8.2.2 Additional tests when needed

- Abdominal radiographs, VD and lateral. Include hip and lumbar spine of geriatric individuals to screen for arthritic changes. Oblique views of teeth taken with jaws open to screen for dental pathology is recommended.
- Abdominal ultrasound to assess abdominal organs (liver pathologies)
- Cardiovascular status (age and history dependent, > 30 years recommended), using electrocardiogram, echocardiogram, and blood pressure measurements

2.8.2.3 Calming animals for transport

Good preparation is the best way to calm a chimpanzee for transport. Crate training allows the individual animal to get used to the crate and avoids an additional anaesthesia for loading. An experienced keeper who the chimpanzee trusts, should accompany it on the transport. The keeper can help to calm the animal and the chimpanzee is more likely to readjust to new surroundings if a familiar person is present and if their usual routine is maintained.

Medical calming during transport is a controversy. A possible option is the use of neuroleptics (see section 2.8.5 below). Currently no specific recommendation is made due to the unknown side effects especially during flight. Thus, a careful individual assessment should be done, and decision made on individual advantages and disadvantages.

2.8.3 Quarantine

2.8.3.1 General

Institutions holding chimpanzees must have holding facilities or procedures for the quarantine of newly arrived animals and isolation facilities or procedures for the treatment of sick/injured animals. Quarantine facilities must be able to safely house chimpanzee(s) for the duration of their quarantine period. All safety and health requirements of regular housing must be maintained in quarantine quarters but because of the short-term duration of a chimpanzee's stay, the available space may be smaller. As such, extra attention should be paid to creating a stimulating environment for the chimpanzee especially if that individual is housed alone. Chimpanzees should not be housed as an animal by itself if it can be avoided. Under certain conditions separation is necessary for untrained animals and for the health of the remaining group. A partner animal can then be beneficial and should be considered. In some cases, when appropriate and safe quarantine facilities are not available at the receiving institutions, quarantine may be conducted at a nearby institution with appropriate coordination of the veterinary staffs of the sending, receiving and intermediary facilities. All quarantine procedures should be supervised by a veterinarian.

If a specific quarantine facility is not present, then newly acquired animals should be kept separate from the established collection to prohibit physical contact, prevent disease transmission, and avoid aerosol and drainage contamination.

Decision on quarantine measurements, length and required testing needs to be based on the overall risk, the disease status of the receiving and sending collection. In case of questions please contact the EEP coordinators and/or the EEP vet advisors.

2.8.3.2 Quarantine protocols

2.8.3.2.1 Receiving facility and preparation

As part of the quarantine evaluation, the group that the quarantined animal will enter should have known status for the infectious agents of concern. This is managed through routine physical examinations and documented in their medical history. For the new animal, quarantine begins with a thorough review of the medical records and social history of the individual, its source group, and collection history.

2.8.3.2.3 Recommended quarantine examination

The quarantine examination should be similar to the opportunistic examination and should include a minimal set of specific diagnostic tests. Disease status of the sending and receiving population, the medical history should be considered to add any additional diagnostics.

Animals should be permanently identified and their ID should be confirmed by their natural markings and/or transponder. A complete physical, including a dental examination if applicable, should be performed. Animals should be evaluated for ectoparasites and treated accordingly. Blood should be collected, analysed and the sera banked in either a -70°C freezer or a frost-free -20°C freezer for retrospective evaluation. Faecal samples should be collected and analysed for gastrointestinal parasites and the animals should be treated accordingly. Vaccinations should be updated as appropriate, and if the vaccination history is not known, the animal should be treated as immunologically naive and given the appropriate series of vaccinations.

A tuberculin testing and surveillance program must be established for animal care staff as appropriate to protect both the health of both staff and animals.

Release from quarantine should be contingent upon normal results from diagnostic testing and negative faecal tests.

In case of any chimpanzee death in quarantine, a full necropsy (gross and histopathology, adequate additional laboratory diagnostics, storage of tissue samples) must be performed to determine the cause of death and the subsequent disposal of the body must be done in accordance with any local or federal laws.

2.8.3.2.4. Quarantine access and protective equipment

Working in quarantine requires special disease prophylaxis training. Additionally, access to the quarantine area must be restricted to a minimal number of authorized personnel. Keepers should be designated to care only for quarantined animals if possible. If keepers must care for both quarantined and resident animals of the same class, they should care for the quarantined animals only after caring for the resident animals. Equipment used to feed, care for, and enrich animals in quarantine should be used only with these animals. During the quarantine period, personal protective equipment (e.g., latex gloves, surgical masks, working gear worn only in the quarantine area, and a footbath placed for use upon entering and leaving the quarantine area) should be used. Ideally footwear should be changed (preferably in combination with liquid footbaths) since walk-through liquid footbaths alone are usually not used in a way to be effective. Disinfection techniques for equipment and devices are similar to recommendations for all other nonhuman primates (CCAC guidelines: Nonhuman primates, 2019; Heuschele 1995).

2.8.4 Capture, restraint and immobilisation

2.8.4.1 Precautions with anaesthesia

Training allowing hand injection for anaesthetic induction in chimpanzees could prevent the excitement of darting. Oral premedication can also reduce the excitement. Different protocols are available in the literature.

Unique respiratory anatomical features include laryngeal air sacs in all great apes. These air sacs are prone to bacterial and yeast infections. Laryngeal air sacculitis could complicate general anaesthesia due to the risk for fatal pneumonia from the aspiration of purulent material. Thus, it is always important to expect the worse and intubate chimpanzees immediately after induction in upright (sitting) position, and not in the easier emergency room style to reduce risk of aspiration. Apes should be intubated with cuffed endotracheal tubes, and the condition should be treated prior to any elective anaesthesia. It is advisable to check for accidental single bronchial intubation by bagging the animal and listening for bilateral breath sounds and /or using chest radiographs.

Cardiovascular diseases are a significant cause of morbidity of captive great apes. Age and obesity are two main risk factors for cardiovascular diseases. These conditions could complicate anaesthesia or result in anaesthetic death. All chimpanzees should be carefully evaluated prior to anaesthesia, and carefully monitored during the procedure.

Chimpanzee females in oestrus develop large genital tumescence, this swelling of the sexual skin can be quite prominent and is very vascular and friable. Care must be taken to avoid darting this area as severe haemorrhage may result

Animals should be fastened for 24 hours. Animals may eat bedding. Thus, an early morning procedure before feeding and after separation from group is recommended. Significant increases in blood pressure with increasing age have been reported in chimpanzees, necessitating closer monitoring in older individuals to detect possible hypertension. If in doubt, contact the veterinary advisors or the ape heart project for further advice.

Proper positioning is essential to ensure patent airways. For longer procedures positive pressure ventilation should be considered

Animals with pain do not eat and thus will not take the necessary medication post operatively. Thus, analgesia should always be provided initially before surgery and in a multi-modal, pre-emptive manner. Injectable opioids and NSAIDs in addition to local anaesthetics will provide significant analgesia, e.g. Buprenorphine, Meloxicam, or

Ketoprofen have a good effect without apparent adverse effects. Consider also the recovery time during the period where the animal does not eat. Oral human formulation (e.g., Ibuprofen, Naproxen, Tramadol, or Meloxicam) can be used for follow-up.

2.8.4.2 Restraint

Physical (or manual) restraint can be very stressful to chimpanzees and dangerous for the humans trying to hold the animal and is not recommended. Positive-reinforcement training programs can facilitate crating of the animals, and the ability to hand-inject chimpanzees for anaesthetic induction and thus can reduce/avoid the excitement of darting.

2.8.4.3 Chemical immobilisation

Whenever possible animals should be fastened for 12-24h before any anaesthetic procedure. Oral premedication (e.g., Midazolam, Diazepam) allows easier immobilisation with less excitement during darting.

Typical immobilization agents for chimpanzees included Telazol (Tiletamine-zolazepam), Ketamine, or combination of these products with Medetomidine, Xylazine, Benzodiazepines (Diazepam or Midazolam), or Butorphanol.

Quiet induction time is essential, and veterinarians should ensure that the patient is fully unconscious before accessing the animal. In procedures longer than 30 minutes good anaesthetic control is essential. Thus, it is recommended when having access to the animal a quick vital check should be followed by intubating the animal, gaining iv access and instrumenting the animal for monitoring. Anaesthesia can be maintained by inhalant agents such as isoflurane or sevoflurane in oxygen.

Anaesthesia monitoring is mandatory. Heart rate and rhythm, pulse quality, capillary refill time (CRT), breathing (respiration depth and rate), and body temperature, are the minimal dataset. For longer procedures, EKG, pulse oximetry, capnograph and blood gas analysis should be added.

During recovery, chimpanzees should be positioned also in lateral recumbency to minimize risk of aspiration.

2.8.5 Use of neuroleptics

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

2.8.5.1 Categories and use of neuroleptics

Neuroleptics, also referred to as antipsychotics in human medicine, include butyrophenones (Haloperidol and Azaperone), phenothiazines (Perphenazine, Fluphenazine), thioxanthenes (Flupentixol, Zuclopenthixol) and substituted benzamides (Sulpiride). These drugs cause a range of degrees of sedation, alpha-adrenoceptor blocking activity, extrapyramidal and antimuscarinic effects (Brearley *et al.* 2001). These drugs generally tranquilise without affecting consciousness or excitement but should not be regarded merely as tranquilisers. In the short term, in humans, they are used to calm disturbed patients whatever the underlying psychopathology.

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

Drug selection in human medicine is based upon the degree of sedation required and the patient’s susceptibility to extrapyramidal effects. This susceptibility is generally unknown when dealing with great apes. Prescribing more than one antipsychotic at a time is not recommended unless under close medical supervision as it may increase the hazard and there is no evidence that side effects are minimized.

Given the lack of data in great apes, it is likely that a number of regimes may be tried before one suitable for the particular patient and condition is found. In particular, care should be taken to selecting the drug regimes in a certain order to avoid potentially dangerous drug interactions. It should therefore be obvious that these drugs should be carefully selected for use in great apes as they do not pose a simple and safe solution to the behavioural management of zoo animals. However, when used carefully they can provide an extra tool for managing difficult cases which are unresponsive to behavioural therapy alone.

2.8.6 Diseases of concern in chimpanzees

Heart disease and renal failure are common causes of mortality in chimpanzees. Respiratory illness, parasitic infections, and traumatic injuries (typically inflicted by another group member) are also commonly seen.

2.8.6.1 Viruses

Adenoviruses can cause severe pneumonia in new-born chimpanzees in colonies with secondary bacterial infections. Cultures from throat swabs are possible.

Herpes simplex virus (herpes hominis) 2 is normally carried in wild chimpanzees, nevertheless staff members with active Herpes simplex lesions should not work with chimpanzees. Human herpesvirus -1 has caused disease in chimpanzees.

Chimpanzees seem to be more robust against **measles**. The human measles vaccine can be used in chimpanzees. Vaccination of staff should be considered.

Viral hepatitis is transmitted by faecal and oral and body fluid transmission. Clinical signs are fever, haemorrhage and hepatitis. Spontaneous infection with HAV and HBV occur in chimpanzees with both human and primate strains, cross-infection is possible. Humans seem to be the primary reservoir for HBV. Although most infected chimpanzees develop antibody titres with rapid antigen removal, some individuals may remain antigenemic and become chronic carriers and pose a significant zoonotic risk. Serologic testing is available and complex. Vaccination is available.

Hepatitis C causes chronic infections in chimpanzees and may result in chronic active hepatitis, cirrhosis, or hepatocellular carcinoma. RNA PCR for screening is available. Vaccine trials have been so far unrewarding.

Chimpanzees can be antibody positive for **Simian T-cell Leukaemia Virus** (STLV-1) can cause lymphoma and immunosuppression.

Chimpanzees have 2 lineages of **Simian Immunodeficiency Virus** (SIV). *Pan t. troglodytes* may be the origin of HIV – 1.

Papillomavirus leads frequently to oral papilloma in chimpanzees. Lesions can be extensive but are usually self-limiting.

2.8.6.2 Bacteria

Campylobacter, Shigella, Salmonella or *Yersinia* species can lead to severe diarrhoea. Regular screening or in case of disease, fresh samples should be collected using an appropriate transport medium and timely analyses in the laboratory is necessary.

Bacterial pneumonia is commonly seen secondary to human viral pathogens. *Streptococcus pneumoniae* requires antibiotic treatment and prophylaxis of exposed individuals. Vaccination is ineffective.

Streptococcus pneumonia is most frequent cause of bacterial meningitis in great apes, sometimes in association with parainfluenza type 3 infection.

Bordetella pertussis (whopping cough) has been reported in chimpanzees. Unfortunately, vaccine seems not work in chimpanzees.

Chimpanzees are also susceptible to tuberculosis and the population should be monitored regularly. Chimpanzees can be screened with intradermal testing and radiographs of the lungs in upright position, culture of material recovered from bronchial washings and gastric lavage. Newer blood tests like Gamma interferon are getting more reliable (see above).

2.8.6.3 Fungi

Fungal diseases are not common in chimpanzees.

2.8.6.4 Parasites

2.8.6.4.1 Echinococcosis

This is a zoonosis of the northern hemisphere caused by larval forms of *Echinococcus* (E.) tapeworms found in the small intestine of carnivores. Among the recognized species, two are of medical importance – *E. granulosus* and *E. multilocularis* – causing cystic echinococcosis and alveolar echinococcosis in humans and non-human-primates. Primates are accidental host and become infected with the ingestion of *Echinococcus* eggs, which are found in with from carnivores contaminated food items (vegetables, fruits collected from ground, sored branches), bedding material or soil. In great apes, gorillas and chimpanzees seem to have an increased susceptibility. Diagnosis is by serology and abdominal ultrasound, although CT scans might be necessary to detect larval migration to other organs than liver. Infected great apes do not spread the parasite and poses no risk to the other animals. There is no best treatment. Radical surgical removal is recommended but in advanced stage usually not possibly, thus chemotherapy with Albendazole for more than 24 months (or permanent) to inhibit growth is recommended. Prevention is the key factor. All vegetables and fruit items should be thoroughly washed, branches should be immediately transferred into the animal enclosure with minimal ground contact outside the enclosure, substrate like bark mulch, should be heated to > 65°C for more than 180 min. Exclusion of foxes and cats from primate facilities are recommended (e.g., fox proof fencing), if not possible regular deworming of native foxes or stray cats with baits has shown better success than culling.

2.8.6.4.2 Strongyloides, Entamoeba and *Balantidium*

are most problematic parasites for many captive chimpanzee colonies. *Entamoeba* and *Balantidium* may be commensals but can cause disease during times of stress. Diagnosis of *Enterobius* may be suggested by intense anal itching, but may not be apparent on routine faecal flotation. During anaesthesia for evaluation, clear adhesive tape can be applied to the anus and perineum to retrieve eggs and make a confirmatory diagnosis.

Rotating anthelminthic products can be considered for recalcitrant infections.

Balantidium coli is a ciliate protozoan and is widespread in chimpanzee colonies. The protozoan invades the enteric mucosa once epithelial barrier has been damaged. Clinical signs range from asymptomatic to diarrhoea ranging from loose stools to dysentery, haemorrhagic diarrhoea and death. Lesions in colon can appear similar to

Entamoeba histolytica. Important are routine faecal examinations for parasites, with wet mounts and stained smears. Dirt/grass enclosures in which animals remain long-term without rotation pose challenges to manage *Balantidium coli* infections. Thus, consider periodic substrate removal/replacement where feasible, including control of intermediate hosts or other vermin that can act as mechanical vectors.

Routine anthelmintic treatment with Tetracycline, Iodoquinol (not well absorbed therefore will not be effective in invasive disease), Metronidazole.

In general, routine cleaning of impervious surfaces, replacement and sufficient amounts of natural substrate is important for control of endoparasites. As chimpanzees can be prone to coprophagy, daily removal of faecal material is necessary, and increased provision of environmental enrichment can assist with reduced completion of parasite life cycles.

2.8.6.4.3 Diabetes

Type 2 diabetes mellitus (T2DM) is the most common form of diabetes seen in non-human primates (e.g., chimpanzees and orangutans). Risk factors are old age, obesity, hormonal (pregnancy, menopause), stress. Any animal under suspicion for diabetes should be evaluated. Blood glucose levels are influenced by stress, handling and anaesthesia and, therefore, need to be interpreted carefully. Glucosuria and ketonuria might be an indicator for further evaluation. Insulin levels can be measured with standard human assays. Treatment is similar to human medicine and should also include a careful evaluation of the diet.

2.8.6.4.4 Heart disease

Please consult the following projects for most recent information:

- Ape Heart Project
- Great Ape Heart Project
- International Primate Heart Project

2.8.6.4.5 Renal failure

Renal failure is a common cause of mortality in chimpanzees.

2.8.6.4.6 Laryngeal air sacculitis

Diagnosis and treatment of laryngeal air sacculitis in chimpanzees is similar to orangutans, but chimpanzees seem to be less frequently affected.

2.8.6.4.7 Dental disease

Dental diseases are frequently seen, such as broken canines with exposed roots, or dental tartar caused by poor nutrition and caries. Prevention is essential with proper nutrition with the possibility of dental cleaning.

2.8.6.4.8 Hypothyroidism

Hypothyroidism has been reported in chimpanzees and can be treated with known human oral therapeutics.

2.8.6.4.9 Vitamin D deficiency

Chimpanzees are susceptible to vitamin D deficiency if they are housed away from natural sunlight. Dietary supplementation via commercial pellets containing adequate vitamin D levels, should be standard. For chimpanzees that are housed inside for extended periods; whether due to winter regimes during introductions, extra supplementation with oral vitamin D might be necessary. Vitamin D deficiency has been implicated in issues with immune system, reproductive systems and heart disease and should therefore not be merely associated with bone issues. There have been cases of fractures, bent bones or seizures in suckling infants. Oral vitamin D can be given in suckling infants, even when not yet eating solids if they can be trained to take oral drops from the staff.

2.8.7 Bite injuries

Traumatic wounds are not uncommon in socially housed chimpanzees. These injuries can result from normal hierarchy disputes as juveniles mature, during introductions of new group members, or in groups with stable membership. Behavioural assessments of groups and individuals are important to minimize injuries or delays in introductions. Operant conditioning may facilitate resolution of this social altercation, but other emergency procedures should be prepared in the event of serious altercations. Only in serious traumatic wounds is anaesthesia required for direct management, including thorough cleaning, debridement, and lavage. Primary closure of the wound should be considered by depth and effect on a particular area, with caution not to entrap infectious debris or create an anaerobic environment. Post-operative lavage or topical treatment of open wounds may be possible with operant conditioning and can use diluted antiseptics (such as Chlorhexidine or Povidone-iodine) or topical agents.

2.8.8 Neonates

All healthy infants should be left with their mothers for nursing and social rearing. The most common illnesses associated with chimpanzee neonates are hypothermia, dehydration, electrolyte imbalance, enterocolitis, respiratory disease, and urological disturbances. Some neonates may have a primary illness due to prematurity, infectious disease, or congenital defect, and may also be neglected. In case of neonates requiring nursery care or treatment the EEP coordinators should be consulted immediately for advice. Pulled neonates need to be housed in an incubator until the infant can maintain its own body temperature. Neonatal fatalities should be necropsied to identify cause of death, congenital problems or maternal-neonatal incompatibility.

2.8.9 Geriatric chimpanzees

Maintenance of good body condition in geriatric chimpanzees is essential. Special nutritional needs and group dynamics needs to be evaluated and diet and feeding practice needs to be adapted. Common age-related health issues in geriatric chimpanzees include musculoskeletal problem, renal disease or cardiac failure, and these may require further specific adaptations of the diet through supplements or restrictions. Musculoskeletal problems may also require furniture adaptations.

The welfare of the geriatric chimpanzees, this includes besides medical aspects (e.g., pain, treatment stress), as well social (e.g., isolation, communication), behavioural (e.g., climbing, grooming) and breeding (e.g., space, genetics), should always be evaluated. Humane euthanasia should be considered as an option where long term welfare is compromised.

Prior to any invasive medical or surgical treatment with long term implications of any chimpanzee the prognosis and long-term welfare of the individual animal must be considered and, if in doubt, discussed with the responsible EEP coordinators and veterinary advisor.

2.8.10 Preventative health care program

An appropriate chimpanzee preventative health care program includes proper animal husbandry and veterinary care based on these current professional standards and addresses the complete physical and behavioural well-being of the animals. Due to the close taxonomic relationship to humans, chimpanzees are susceptible to many human diseases. Close contact between the public and chimpanzees in zoological facilities should be minimized because of possible disease transmission. Carriers of sub-clinical infections can transmit diseases to naive conspecifics, but also to humans. Thus, a preventive health care program addresses the health of both the chimpanzees and the animal care staff.

The goal of a preventative health program should improve the health of individual chimps, prevent disease introduction into the population reduce the necessary medical care for both humans and chimpanzees, and thus improve the overall well-being of the animals. The preventative health program should consist of: (1) quarantine, (2) review of detailed medical records and daily observations, (3) routine opportunistic physical and diagnostic examinations, (4) vaccinations, (5) proper nutrition, (6) employee health program, and (7) pest control.

2.8.10.1 Quarantine

Quarantine procedures are descripted above and must be regularly adapted to current disease risk situation.

2.8.10.2 Review of medical histories and daily observations

Medical records are an essential part of the preventative health program. They provide important information on the health and disease situation of the population. Thus, animal and medical records for each animal should be accurately maintained and easily available. The current Species360 system with the medical module allows easy data sharing and provides a good and secure solution.

In addition, keepers should assess the health and behaviour of the chimpanzees in their care by daily observations. Careful inspections of each individual, how it relates to its conspecifics, appetite, eliminations, and detecting signs of injury or disease should be made by keepers each day, and, these observations should be documented to ensure continuous information transfer and should be provided to the veterinarian within 12 hours of completion.

Operant conditioning programs could allow gaining additional health information, such as, weighing, oral inspection, injection presentation, and auscultation.

2.8.10.3 Physical and diagnostic examinations

In a healthy population, it is currently not common to perform routine physical examinations of all chimpanzees in a group at 18-24-month intervals. Thus, opportunistic examinations need to be more extensive and should allow additional health information, exceeding the current need. This procedure will require full anaesthesia of the animals for their safety and that of their caretakers. Once the animal is induced and stabilized, full examinations should include both visual assessment and palpation systematically. Examinations should also include thoracic auscultation, deep transabdominal palpation, and use of an appropriate instrument to examine eyes, ear canals, nasal passages, and the vaginal vault for female chimpanzees. Dental examination should follow common techniques and documented in a dental chart. Gingival tissues should be closely monitored for development of periodontal disease. Broken teeth or teeth with exposed root canals should be evaluated for extraction or endodontic treatment.

Blood collection:

Blood collection is accomplished typically from the median cubital, cephalic, basilic, femoral, or saphenous veins, and is used for complete blood count (CBC), serum chemistry panel, viral serology, blood typing, serum and biobanking in the EAZA Biobank for all ages, thyroid assessment, cholesterol, triglycerides, and lipoprotein concentrations, and cardiac markers for adults, especially those over 30 years of age. Representative serum values from a study of captive chimpanzees can be found in Howell *et al.* (2003) and in the 360species medical database.

Faecal samples:

Bacteriology: Faecal samples or rectal cultures should be collected routinely for cultures of *Shigella*, *Salmonella*, *Campylobacter*, and *Yersinia*. This culture panel should be assessed in animals with refractile diarrhoea or diarrhoea with other clinical signs of systemic illness.

Parasitology: Routine monitoring for endoparasites by faecal flotation should be performed at least twice yearly to monitor seasonal variation. Samples should be collected native and in SAF (Sodium acetate-acetic acid-formalin) solution. At each evaluation, two samples, separated by several days should be collected to monitor for intermittent shedding. Evaluations should include sedimentation and direct faecal smears for more complete assessment. During quarantine periods, faecal samples should be evaluated by at least three samples taken at weekly intervals. Based on these results, and the baseline history of the group and collection, specific antiparasitic treatment can be prescribed. Over-treatment or ineffective treatment regimens can contribute to persistent diarrhoea through disrupted gastrointestinal bacterial flora. Complete elimination of endoparasites is often not the expected goal, but rather control of clinical signs and reduction of endoparasitic numbers.

Diagnostic imaging:

Radiographs of the thorax and abdomen should be imaged in two views (lateral and dorsoventral/anteroposterior) with the limbs extended from the view. Any skeletal areas of concern or prior injury should be imaged. Abdominal ultrasound should be routinely performed, with rectal ultrasound or other advanced imaging scheduled when needed diagnostically. Due to increasing identification of cardiac disease in this species, complete cardiac assessment is important, and should include an EKG, blood pressure measurement, and echocardiography.

Mycobacterial testing:

All chimpanzees should be tested for mycobacterial disease. If all animals of the group have been tested, opportunistic tests are recommended.

Mycobacterial (tuberculosis) testing should be thorough in groups of unknown history or with known mycobacterial history. It should include minimally an intradermal testing with MOT (mammalian old tuberculin) with a saline or APPD (avian purified protein derivative) in a contralateral location. The usual location for test administration is the palpebrae for ease in reading the test at 24-hour intervals for three days; however, naturally naked, thin skin (such as the areolae), or shaved and minimally thickened skin can be utilized with animals trained to present these body parts. Additionally, a tracheal (best bronchoalveolar) and gastric lavage should be collected for mycobacterial culture and send to an experienced laboratory. Thoracic radiographs should be closely inspected for characteristic lesions of lymph node enlargement, as this bacterial infection is routinely found as a respiratory disease from inhalation of *Mycobacteria tuberculosis*, or lymphoid infection in atypical mycobacteriosis. Whole, heparinized blood can be submitted for interferon testing (Primagam) for evaluation of serologic evidence of mycobacterial infection.

2.8.10.4 Vaccinations

The vaccination program depends on the region, available vaccines, collection and design of enclosures. Under certain circumstances, it might be recommended to vaccinate chimpanzees against tetanus, measles and poliomyelitis and other infectious diseases (refer to veterinary advisor). Separate protocols for juveniles and adults should be developed and maintained. Hand-raised infants may require additional vaccinations due to the intensive direct human contact. Rabies vaccination can be considered when necessary.

Whenever possible, killed vaccination products should be utilized for vaccinating chimpanzees, rather than modified-live (MLV) products. It is particularly important to note that neither efficacy nor safety has been confirmed formally for these vaccination products in chimpanzees.

Tetanus:

Three intramuscular doses of tetanus vaccine are given at 2-3-month intervals, starting at 3 months of age. Intramuscular boosters are given after 5 years and at 10-year intervals thereafter.

Poliomyelitis:

Three doses of live trivalent polio vaccine are given at 2-3-month intervals started at 3 months of age. Oral boosters are given after 4-6 years. It is important to give the oral polio vaccine to all primates in a group at the same time.

Measles:

A series of two doses MMR (Measles, mumps, rubella) if possible is practical and safe. Vaccinate at 6 and 12 months of age or one at 15 months of age, booster at 6-7 years (not in pregnant animals, risk of foetal infection)

Note: Live virus vaccines can interfere with the response to tuberculin testing.

It is not recommended to administer rubella vaccinations to pregnant or non-contracepted, reproductively active females. Do not vaccinate against tuberculosis. BCG confers variable protection in man and non-human primates.

Tetanus and poliomyelitis have yet to be reported in European chimpanzee collections. Chimpanzees seem also to be more robust against measles infection. Thus currently, routine vaccination is not routine.

2.8.10.5 Nutrition

A good, balanced diet for all life stages taking also the enrichment and animal needs into consideration is essential. For further details, please see the Nutrition Chapter (section 2.2).

2.8.10.6 Employee health program

Employees should be aware of the zoonotic disease risk. Healthy animals and employees are the best prevention to maintain good health in the population. Thus, it is essential that all staff members working with chimpanzees are in good general health and all vaccinations are current. Staff who are immunosuppressed for any reason (e.g., chemotherapy, HIV infection, pregnant) should not be working with chimpanzees.

Sick staff members should not work with chimpanzees or prepare food. Especially staff with children or other family members suffering under infectious diseases like measles, mumps, chicken pox, scarlet fever, student kissing fever (mononucleosis, EBV) should not work.

All injuries, accidents and illnesses of staff should be recorded. Bites and scratches should be immediately (stop work) thoroughly washed (not scrubbed) and medical attention sought if severe.

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 chimpanzees.

2.8.10.7 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 vegetation, ponds and moats which may require constant attention in this respect. Organisms such as *Shigella*, *Salmonella*, *Campylobacter*, *Chlamydia*, *Leptospira*, *Yersinia* and even nematodes such as *Angiostrongylus* and *Capillaria* can all be introduced or spread by pest species. In endemic areas of *Echinococcus* spp. dogs and foxes might cause serious problems by contaminating outside enclosures, bedding material, material for behavioural enrichment and even food. Deworming these animals living on zoo grounds on a regular basis is essential when exclusion is not possible.

2.8.11 Reproduction

2.8.11.1 Pregnancy testing

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

2.8.11.2 Contraception

See 2.4.1.3 Contraception possibilities.

2.8.11.3 Non-breeding females

2.8.11.3.1 Hormonal assessment

Non-invasive methods for monitoring and assessing reproductive status have been developed. In general, sex steroid hormone metabolites (oestradiol, progesterone) can be measured in urine or faeces; both methods are used to monitor gonadal function or pregnancy. Also, testosterone metabolites can be measured to monitor testicular activity in males. Some specialised laboratories have established validated methods and baseline data for chimpanzees

Generally, ovulation occurs mid-cycle and the human ovulation tests will work as well in chimpanzee. Best is to collect first-voided morning urine, if possible, for 3-5 days during mid-cycle.

2.8.11.3.2 Fertility treatment for non-ovulating chimpanzee females

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

2.8.12 Post mortem examination

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

1. Ensure a full post-mortem examination is performed (see underneath).

2. Ensure sample collection for all EAZA approved research projects

3. Ensure to recover and store gametes when possible (See: 2.4.1.7.2 Gamete Recovery)

4. Inform the GATAG vet advisor (send completed post mortem report, studbook keepers and send copies of the results)

5. Arrange for all surplus samples to be sent to the EAZA Great Ape Biobank

A thorough post-mortem examination with further diagnostics according to the Standardised necropsy report for great apes should be carried out by a competent and experienced pathologist or veterinarian without unnecessary delay. Chimpanzee anatomical specialities should be known and inspected. Particular care should be taken with chimpanzees dying in quarantine as these animals must be assumed to be of high zoonotic potential until proven otherwise.

A standardized necropsy protocol for great apes is provided and recommended by the Great Ape TAG.

Important is to measure and describe all organs as well when appear normal. If certain body parts will not be dissected due to specimen preservation a post mortem CT scan should be carried out to establish references and to find any abnormalities.

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

2.8.13 Veterinary advisor contact details

Hanspeter W. Steinmetz
Dr. med. vet.; M.Sc. WAH; Dipl. ACZM; Dip. ECZM
European Veterinary Specialist in Zoological Medicine
Munich Zoo

Romain Potier
DVM, DipECZM (ZHM)
European Veterinary Specialist in Zoological Medicine
FauneVet
22 rue René Viviani, 44200, Nantes, France

2.9 Specific Problems and Recommended Research

Christina Hvilsom, Louise Cox, Francis Cabana, Hanspeter Steinmetz, Romain Potier, Jana Pluhackova, Tom de Jongh

2.9.1 Specific Problems

- In changing the composition and size of the groups (see also section 2.3.2), the natural social life should be our model. Young males should stay in their natal group for their entire lifetime, unless either the capacity of the facility is at stake or if they are urgently needed in another participating zoo for breeding purposes.

  Chimpanzees have historically been kept predominantly in relatively small groups with one adult male and a few adult females. Young born and raised in these groups were often transferred to other institutions before they reached adolescence. This was particularly the case regarding young males. As a consequence, the single male could not participate in the typical close bond that chimpanzee males maintain with each other. Also, young females, if they remained in the group, would produce inbred offspring sired by their own father. These groups would also need the introduction of a new adult male to succeed the alpha male after his death instead of a natural succession of that position by his own progeny as it happens in nature.

  In nature, young males have to find their position among a large number of adult males. That will take considerable time and the young males can very gradually find their place in the male hierarchy. In the zoo groups as described above, a single adult male and the adult females of the group often are not capable of controlling the adolescent behaviour of young males. This is in particular true if the adults have already reached a high age before a young male has reached his adolescence.

  Day to day social life very much benefits from a large group, including both multiple males and multiple females. Such a group offers a much richer social environment for this very social species and also benefits from being much less vulnerable for stochastic events. There is more stability.

  However, changing the group size and composition accordingly is often not easy, since the individuals lack the experience to cope with such changes and since the initial changes are the most drastic ones.

- Introduction can be a very sensitive and exhausting long-term process that needs to be carried out in a careful way with the help of Chimpanzee EEP introduction advisors (see section 2.7)

- The presence of non-breeding males in groups that also have potential for one of the breeding programmes. These males are often interfering with reproduction for those programmes, in particular if they are in a position where they can potentially reach a higher position in the hierarchy.

- In the EEP we see that many females show maternal neglect, or inexperience with appropriate maternal care for their offspring. There seem to be several factors contributing to this problem:

  - The limited social background of many females. Preferably, young females should have hands-on experience with the care for new-borns when alloparenting for younger siblings or young from socially close females. Many of the females in the EEP were born in lab conditions, in circuses, in zoos with small groups of inexperienced females, or were kept by private holders. Many of the older females were wild caught at a very young age and kept with others of similar age instead of with adults and the same is true for females that were born in zoos and hand reared.

The introduction of a female that has successfully raised young before, to serve as an example for the females that lack such experience may be of value, but only if close bonds between those females will be made. When possible, young females should stay in their natal group until they have had the chance to see their mother raise a sibling.

- The social position of the female in the group. In particular, the anticipation of possible infanticide seems to discourage low ranking females to take care of their new-borns.

- The social dynamics in the group. Chimpanzee groups go through calm and relaxed periods, but also through periods with tension in the group, often related to changes in the hierarchy. The stress seems to affect the maternal behaviour of some females.

Facilities that offer females the possibility to separate themselves from certain group members can be helpful. In nature, low ranking females avoid infanticide on their new-borns by reducing their association with adult males in general, and to a greater extent with both low-ranking males and those rising in rank from a position where paternity of current infants was unlikely, to a rank where the probability of siring the next infant is significantly higher" (Lowe *et al.* 2019). Lowe *et al.* (2019) also found evidence that females preferentially associate with a potential protector male during high-risk periods. In this light it might be considered to separate a female that is due to give birth and for which the social situation may be a cause of stress, preferably in the company of a close female friend, for the first weeks of the new-born's life.

- A relatively high number of neonate deaths. During the last ten years (April 2012-April 2022) There has been an unwanted high level of neonate mortality that urgently needs addressing.

- Although chimpanzees can and should be kept in groups with multiple males and multiple females, the EEP has to deal with a large number of surplus males (see also section 2.3.2). There are several causes for this issue:

  - Many facilities have too limited space for a group with equal numbers of both sexes.

  - In some facilities, nearly all of the offspring that was born and raised is male. Obviously, the chance that this is the case in a relatively small group is higher than in a large group.

  - Non-breeding males can become surplus if they dominate potential breeding males and keep these from breeding.

  - In smaller groups, the behaviour of a single adolescent male can become problematic at an earlier stage compared to in a large group.

- The growing number of zoos that intends to stop keeping chimpanzees. For females it is much easier to find a suitable destination, but also these zoos have one or more males that also need a place.

- Combining the need to optimise the reproduction for the *P. t. verus* and *P. t. troglodytes* breeding programmes with the reduction in space due to programme participants stopping with this species, and, as a consequence, the challenge to offer perspective and motivation for the many participants that cannot be included in those breeding programmes yet and are keeping groups of hybrids and other non-reproducing chimpanzees.

- Chimpanzees are seen by some zoos as problematic noisy species with complicated social life and a high level of aggression. This, together with the necessary long-time breeding moratorium, causes reduced attractiveness of this species for both some current and potentially new holders.

- The EEP is challenged to stimulate zoos to improve their facility, if possible, while coordinating the transfers of the individuals that can no longer be kept in their current housing. This is a common challenge for the holders also, and cooperation and solidarity are crucial to meet this challenge.

- Heart diseases (in particular Cardiac fibrosis) is one of the main causes of deaths in zoo chimpanzees, contrary to wild chimpanzees. Thanks to the research in the Ape Heart Project, we are learning more about this disease, although despite extensive post-mortem examinations, no obvious conclusions could yet be identified (Strong *et al.* 2019)

2.9.2 Recommended Research

The chimpanzee EEP encourages and recommends further research to improve the management of chimpanzees in European zoos, as well as support and contribute to conservation research of the *in situ* populations. Scientifically sound, hypothesis driven research, following zoo Research Guidelines (Pankhurst *et al.* 2008) is recommended. If research involves more than one zoo, or if the zoo does not have the resources to review research applications, research applications can be reviewed by the EEP coordinators and advisors, and/or by the Great Ape TAG chairs. The reviewers can provide practical advise on how to conduct zoo research, and evaluate the methodological approach as well as to what extend the research benefits the EEP population or the wild counterparts.

The following topics have been identified as priority for research that benefits the management of EEP chimpanzees:

- **Nutrition**: Understanding the specific nutritional requirements of chimpanzees and how these might vary depending on life stages etc.

- **Nutrition**: Understand diet changes, specifically increased fiber and lower sugar content, and how that can impact regurgitation/stereotypic behaviours.

- **Nutrition**: The need to understand the importance of reflecting seasonal changes in diet to mimic natural variations in high quality versus low quality food and how important the resulting physiological changes are to long term health and reproduction.

- **Breeding *ex situ*:** Research into the causes of the high percentage of stillbirths in EEP chimpanzees.

- **Breeding *ex situ***: Continuing the genotyping of the EEP chimpanzees, to close the remaining gaps in terms of relatedness, paternity and subspecies, in collaboration with the EAZA biobank.

- **Breeding *ex situ***: Research on sperm collection, sperm storage and especially artificial Insemination is high priority, because it potentially can be used to increase genetic diversity in the populations.

- **Health**: Cases of thromboembolism have been identified in chimpanzees both in US and European captive populations. We suspect that this condition might be under-reported. The disease remains largely unknown and although all cases occurred in conjunction with heart diseases, risk factors for the disease need to be established as well as treatment options etc. The interest of thermographic imaging in suspected cases has also been discussed and warrants probably more research.

SECTION 3. REFERENCES & SUGGESTED READING

Abelló, T. 2012. Integrating a hand-reared chimpanzee into an existing group at Barcelona Zoo. *International Zoo News* **59** (3), 201-210

Agnew, M. K., Asa, C. S., Clyde, V. L., Keller, D. L., Meinelt, A. 2016. A survey of Bonobo (*Pan paniscus*) oral contraceptive pill use in North American zoos. *Zoo Biology*. **35**(5):444-453. Doi: https://doi.org/10.1002/zoo.21310

Alford, P.L., Bloomsmith, M.A., Keeling, M.E. and Beck, T.F. 1995. Wounding aggression during the formation and maintenance of captive multimale chimpanzee groups. *Zoo Biology* **14**(4): 347-359. https://psycnet.apa.org/doi/10.1002/zoo.1430140406

Allen, E., Diddle, A. W., Burford, T. H., Elder, J. H. 1936. Analysis of the urine of the chimpanzee for estrogen content during various stages of the menstrual cycle. *Endocrinology* **20**: 546-549.

Ancrenaz, M., Cheyne, S.M., Humle, T. and Robbins, M.M. 2015. Impacts of industrial agriculture on ape ecology. In: Arcus Foundation (ed.), *State of the Apes 2015: Industrial Agriculture and Ape Conservation*, pp. 165–192. Cambridge University Press, Cambridge, UK.

ARAZPA ASMP Primate TAG 2004. Facility Requirements for Orang-utans: A resource Guide.

Atencia, R., Revuelta, L., Somauroo, J.D. & Shave, R.E. 2015. Electrocardiogram reference intervals for clinically normal wild-born chimpanzees (*Pan troglodytes*). *Am. J. Vet. Res*. **76**(8): 688-693.

Atencia, R., Stöhr, E.J., Drane, A.L., Stembridge, M., Howatson, G., Rodriguez Lopez del Rio, P., Feltrer, Y., Tafon, B., Redrobe, S., Peck, B., Eng, J., Unwin, S., Sanchez, C.R. and Shave, R.E. 2017. Heart rate and indirect blood pressure responses to four different field anesthetic protocols in wild-born captive chimpanzees (*Pan troglodytes*). *Journal of Zoo and Wildlife Medicine* **48**(3): 636–644,

Baker, K, and Easley, S. 1996. An analysis of regurgitation and reingestion in captive chimps. *Applied animal behaviour science*. **49**, 403-415.

Baker, K. C., Aureli, F. 2000. Coping with conflict during initial encounters in chimpanzees. *Ethology* **106**: 527–541.

Ban, S., Boesch, C., N'Guessan, A., N'Goran, E., Tako, A. and Janmaat, K. 2016. Taï chimpanzees change their travel direction for rare feeding trees providing fatty fruits. *Animal Behaviour* **118:** 135-147.

Bania, A., Harris, S., Kinsley, H., Boysen, S. 2009. Constructive and deconstructive tool modification by chimpanzees (*Pan troglodytes*). *Animal Cognition,* **12**: 85–95.

Basabose, A. K. 2002. Diet composition of chimpanzees inhabiting the montane forest of Kahuzi, Democratic Republic of Congo. *American Journal of Primatology*, **58:** 1-21.

Bayne, K. 1991. Providing environmental enrichment to captive primates. *Compendium of Continuing Education for the Practicing Veterinarian, North American Edition* **13**: 1689–1695.

Beck, J., & Chapman, H. 2008. A population estimate of the endangered chimpanzee *Pan troglodytes vellerosus* in a Nigerian montane forest: implications for conservation. *Oryx*, **42**: 448-451.

Bernstein-Kurtycz, L. 2015. Choice and control for animals in captivity. *The Psychologist* **28:** 892-894

Besenbacher, S., Hvilsom, C., Marques-Bonet, T., Mailund, T. and Schierup, M. H. 2019. Direct estimation of mutations in great apes reconciles phylogenetic dating. *Nature Ecology & Evolution*. https://doi.org/10.1038/s41559-018-0778-x

Bessa, J., Sousa, C. and Hockings, K. 2015. Feeding ecology of chimps (*Pan troglodytes verus*) inhabiting a forest-mangrove-savanna-agricultural matrix at Caiquene-Cadique, Cantanhez National Park, Guinea-Bissau. *American Journal of Primatology*, **77:** 651-665.

Bettinger, T. L., DeMatteo, K. E. 2001. Reproductive management of captive chimpanzees; contraceptive decisions. In: Brent L. (ed), The Care and Management of Captive Chimpanzees. San Antonio, Texas: *The American Society of Primatologists:* 119-145.

Bettinger, T., Wallis, J. and Carter, T. 1994. Spatial selection in captive adult female chimpanzees. *Zoo Biology* **13**: 167–176.

Bishop, J., Hosey, G. and Plowman, A. (eds.)2013. Handbook of Zoo Research, Guidelines for Conducting Research in Zoos. BIAZA

Bloomsmith, M.A. & Baker, K.C. 2001. Social management of captive chimpanzees. In: Brent L. (ed.), The Care and Management of Captive Chimpanzees. San Antonio, Texas: *The American Society of Primatologists*: 205-242.

Bloomsmith, M. and Lambeth, S. 1995. Effects of predictable versus unpredictable feeding schedules on chimpanzee behaviour. *Applied animal behaviour science*. **44**: 65-74.

Boesch, C. 1994. Cooperative hunting in wild chimpanzees. *Animal Behaviour*, **48:** 653-667.

Boesch, C. 1996. Social grouping in Taï chimpanzees. In: *Great Apes societies,* McGrew, W., Nishida, T., and Marchant, L. (eds.): 101-113. Cambridge University Press, Cambridge.

Boesch C. 1997. Evidence for dominant wild female chimpanzees investing more in sons. *Animal Behaviour* **54**(4):811-815.

Boesch, C. and Boesch, H. 1989. Hunting Behavior of Wild Chimpanzees in the Taî National Park. *American Journal of Primatology*. **78**: 547- 573.

Boesch, C., and Boesch-Achermann, H. 2000. The Chimpanzees of the Taï Forest: Behavioural Ecology and Evolution*.* Oxford University Press, Oxford.

Bogart, S. L., and Pruetz, J. D. 2011. Insectivory of savanna chimpanzees (*Pan troglodytes verus*) at Fongoli, Senegal. *American Journal of Physical Anthropology*, **145**: 11-20.

Bowsher, T. R., Alford, P. L., Kraemer D. C. 1992. Use of artificial vagina to collect chimpanzee semen. *American Journal of Primatology* **27**(1): 18-19.

Brack, M. 1987. Agents transmissible from simians to man. Springer Verlag. Berlin.

Brack, M., Göltenboth, R. and Rietschel, W. 1995. Primaten. In Göltenboth/Klös (Editors) Krankheiten der Zoo- und Wildtiere. Blackwell Berlin.

Bracke, M. B. M., Hopster, H. 2006. Assessing the importance of natural behavior for animal welfare. *Journal of Agricultural & Environmental Ethics,* **19:** 77-89.

Brando, S., Buchanan-Smith, H. 2017. The 24/7 approach to promoting optimal welfare for captive wild animals. *Behavioural Processes* **156**: 83-95. DOI: http://dx.doi.org/10.1016/j.beproc.2017.09.010

Bray, J., Thompson, M., Muller, M., Wrangham, R. and Machanda, Z. 2017. The development of feeding behaviour in wild chimpanzees (*Pan troglodytes schweinfurthii*). *Journal of Physical Anthropology* **165**: 34-46.

Brearley, J.C., Heatrh, S.E., Jones, R.S., Skerritt, G.C. 2001. Drugs acting on the nervous system. In: Bishop, Y. (ed). *The veterinary formulary.* London. 361-414

Brent, L. 1997. Behavioural management of nonhuman primates in a laboratory environment. In: B. Holst (Ed.), *Proceedings of the 2nd International Conference on Environmental Enrichment.* Frederiksberg, Denmark: Copenhagen Zoo: 149–163.

Brent, L. 2001. The influence of rearing condition on chimpanzee introductions. In: The Apes: Challenges for the 21st Century, *Conference Proceedings,* 103-4. Brookfield, IL: Chicago Zoological Society

Brent, L. (ed.) 2001 The care and management of captive chimpanzees. American Society of Primatologists. San Antonio, Texas.

Brent, L., Lee, D. R., Eichberg, J. W. 1989. Evaluation of two environmental enrichment devices for singly caged chimpanzees (*Pan troglodytes*). *American Journal of Primatology,* **Suppl 1**: 65-70.

Brent, L., Eichberg, J. W. 1991. Primate puzzleboard: A simple environmental enrichment device for captive chimpanzees. *Zoo Biology* **10**: 353-360.

Brent, L., Kessel, A. L. and Barrera, H. 1997. Evaluation of introduction procedures in captive chimpanzees. *Zoo Biology* **16**: 335-342.

Britt, S., Cowlard, K., Baker, K. and Plowman, A. 2015. Aggression and self-directed behaviour of captive lemurs (*Lemur catta, Varecia variegata, V. rubra and Eulemur coronatus*) is reduced by feeding fruit-free diets. *Journal of Zoo and Aquarium Research.* **3**(2): 52-58.

Brncic, T., Amarasekaran, B. and McKenna, A. 2010. Sierra Leone National Chimpanzee Census. September 2010. Tacugama Chimpanzee Sanctuary, Freetown, Sierra Leone.

Brown, W. 2012. Human Visitation, Temperature, and Their Effects Upon Chimpanzee (*Pan troglodytes*) Spatial Distribution and Behavior at the Detroit Zoo. Thesis for a Bachelors' degree. University of Michigan

Bryson-Morrison, N., Matsuzawa, T., and Humle, T .2016. Chimpanzees in an anthropogenic landscape: Examining food resources across habitat type at Bossou, Guinea, West Africa. *American Journal of Primatology*, **78**: 1237–1249.
Butynski, T. M. 2003. The robust chimpanzee *Pan troglodytes*: Taxonomy, distribution, abundance, and conservation status. In: R. Kormos, C. Boesch, M.I. Bakarr, T.M. Butynski (eds). *West African Chimpanzees, Status Survey and Conservation Action Plan*: 5-12. IUCN/SSC Primate Specialist Group, Gland, Switzerland and Cambridge, UK.
Butinsky, T., Kingdon, J. and Kalina, J. 2013. Mammals of Africa **2***, Primates*: 53-63
Cabana, F., Jasmi, R. and Maguire, R. 2018. Great ape nutrition: low-sugar and high-fibre diets can lead to increased natural behaviours, decreased regurgitation and reingestion, and reversal of prediabetes. *International Zoo Yearbook* **52:** 1-14.
Caldecott, J. and Miles, L., eds. 2005. World Atlas of Great Apes and their Conservation: 52-81. Berkley, USA: University of California Press.
Carey, J. R., and Judge, D. S. 2000. Longevity Records: Life Spans of Mammals, Birds, Amphibians, Reptiles, and Fish. *Odense Monographs on Population Aging*, **8**, Odense University Press, Odense Denmark
Carlsen, F. 2002. European studbook for the West African chimpanzee (*Pan troglodytes verus*) **Vol 1**. Copenhagen Zoo, Copenhagen.
Carlsen, F. 2007. European studbook for the chimpanzee (*Pan troglodytes*) – western chimpanzee (*P. t. verus*) EEP **Vol 2** & chimpanzee (*P. troglodytes*) ESB **Vol 1**. Copenhagen Zoo, Copenhagen
Carlsen, F. and de Jongh, T. 2009. Getting it right for chimpanzees. *EAZA News* **67:** 22-23.
Carlsen, F., Leus, K., Traylor-Holzer, K., Mckenna, A. (Eds.) 2012. Western Chimpanzee (*Pan troglodytes verus*) Population and Habitat Viability Assessment (PHVA) for Sierra Leone: Final report. IUCN/SSC Conservation Breeding Specialist Group – Europe (CBSG Europe), Copenhagen, Denmark.
Carlsen, F. and de Jongh, T. 2015. European studbook for the chimpanzee (*Pan troglodytes*) 2014 – 1st edition of joint EEP studbook. Copenhagen Zoo, Copenhagen.
Carlsen, F., de Jongh, T. and Leus, K. 2018. Long term management plan for the chimpanzee (*Pan troglodytes*) European *Ex situ* Programme. Copenhagen Zoo, Copenhagen.
Carlsen, F. and de Jongh, T. 2019. European studbook chimpanzee (*Pan troglodytes*) 2018. Copenhagen Zoo, Copenhagen.
Canadian Council on Animal Care, 2019. CCAC guidelines: Nonhuman primates
Celli, M.L., Tomonaga, M., Udono, T., Teramoto, M., Nagano, K. 2003. Tool use task as environmental enrichment for captive chimpanzees. *Applied Animal Behaviour Science* **81**: 171-182.
Chapman, C. A. and Peres, C. A. 2001. Primate conservation in the new millennium: The role of scientists. *Evolutionary Anthropology,* **10:** 16–33.
Chapman, C. A. and Wrangham, R. W. 1993. Range use of the forest chimpanzees of Kibale: implications for the understanding of chimpanzee social organization. *American Journal of Primatology,* **31**: 263-273**.**
Clark, G. and Birch, H. G. 1948. Observations on the sex skin and sex cycle in the chimpanzee. *Endocrinology* **43:** 218-231.
Clark, C. B. 1977. A preliminary report on weaning among chimpanzees of the Gombe National Park, Tanzania. In: Chevalier-Skolnikoff S, Poirier FE. (eds.), Primate bio-social development: Biological, social and ecological determinants. New York, Garland Publishing Inc.: 235-260.
Clark, F. 2011. Space to choose: network analysis of social preferences in a captive chimpanzee community, and implications for management. *American Journal of Primatology.* **73:** 748-757.
Clark, F. E., & Smith, L. J. 2013. Effect of a cognitive challenge device containing food and non-food rewards on chimpanzee well-being. *American Journal of Primatology* **75**: 807–816.
Clingerman, K. J. and Summers, L. 2005. Development of a body condition scoring system for nonhuman primates using *Macaca mulatta* as a model. *Lab Animal. (NY)* **34**:31–36
Cocks, L. 2007. Orangutan Facility Design. In: Sodaro, C. (Ed.). Orangutan Species Survival Plan Husbandry Manual. Brookfield: Chicago Zoological Society. https://www.czs.org/custom.czs/media/CenterAnimalWelfare/Orangutan-Husbandry-Manual/Facility-Design.pdf

Cocks, L. 2001. Orangutan Guidelines. Guidelines for the Housing and Management of Orangutans (*Pongo pygmaeus* and *Pongo abeli*). Perth: Australasian Species Management Program, Primate Taxon Advisory Group.

Coe, J. C., Fulk, R. and Brent, L. 2001. Facility design. In: Brent L. (ed.), *The Care and Management of Captive Chimpanzees.* San Antonio, Texas: The American Society of Primatologists: 39-81.

Conklin-Brittain, N., Wrangham, R. and Hunt, K. 1998. Dietary Response of Chimpanzees and Cercopithecines to Seasonal Variation in Fruit. *International Journal of Primatology* **19**(6): 971-998.

Conklin-Brittain, N., Knott, C, and Wrangham, R. 2006. Energy intake by wild chimpanzees and orangutans: methodological considerations and a preliminary comparison. In: Feeding ecology in apes and other primates. Hohmann, G., Robbins, M. and Boesch, C. Cambridge university press.

Cooper, J., Jackson, R. 1996. A comparison of the feeding behaviour of sheep in straw yards and on slats. *Applied Animal Behaviour Science* **49:** 99.

Coslovsky, M. and Baumeyer, A. 2018. "Chimp transfers; What we can learn from the past"; presented in the chimpanzee EEP meeting at the EAZA annual conference in Athens

Crissey, S. and Pribyl, L. 1997. Utilizing wild foraging ecology information to provide captive primates with an appropriate diet. *Proceedings of the Nutrition Society* **56**: 1083 – 1094.

Crockett, C. 1998. Psychological well-being of captive nonhuman primates: Lessons from laboratory studies. In: Shepherdson, D., Mellen, J. and Hutchins, M. (Eds.), *Environmental enrichment for captive animals.* Washington, DC: Smithsonian Institution Press: 129–152.

Davey, G. 2005**.** Relationship between exhibit naturalism, animal visibility and visitor interest in a Chinese Zoo. *Applied Animal Behaviour Science* **96**: 93–102.

De Jongh, T., Vermeer, J. and Vidakovits, I. 2006.- Gorilla Accommodation. In: EAZA Gorilla EEP- Husbandry Guidelines. EAZA.

Deblauwe, I. and Janssens, G. 2007. New insights in insect prey choice by chimpanzees and gorillas in southeast Cameroon: the role of nutritional value. *American Journal of Physical anthropology* **135:** 42-55.

De Manuel, M., Kuhlwilm, M., Frandsen, P., Sousa, V.C., Desai, T., Prado-Martines, J., Hernandez-Rodrigues, J., Dupanloup, I., Lao, O., Hallast, P., Schmidt, J.M., Heredia-Genestar, J.M., Benazzo, A., Barbujani, G., Peter, B.M., Kuderna, L.F.K., Casals, F., Angedakin, S., Arandjelovic, M., Boesch, C., Kühl, H., Vigilant, L., Langergraber, K., Novmebre, J., Gut, M., Gut, I., Navarro, A., Carlsen, F., Andrés, A.M., Siegismund, H.R., Scally, A., Excoffier, L., Tyler-Smith, C., Castellano, S., Xue, Y., Hvilsom, C. and Marques-Bonet, T. 2016. Chimpanzee genomic diversity reveals ancient admixture with bonobos. *Science* **354** (6311): 477-481

De Waal, F.B.M. 1980. Aap geeft Aapje de fles, in: *De Levende Natuur* **82** (2): 45-54

De Waal, F.B.M. 1998. Chimpanzee politics – power and sex among apes. *The John Hopkins University Press.* Baltimore.

De Waal, F.B.M. and van Roosmalen, A. 1979. Reconciliations and Consolation among Chimpanzees. *Behavioral Ecology and Sociobiology* **5**(1): 55-6

Doran, D. 1997**.** Influence of seasonality on activity patterns, feeding behavior, ranging and grouping patterns in Taï chimpanzees. *International Journal of Primatology* **18:** 183-206

Dutton, P. and Chapman, H. 2015. Dietary preferences of a submontane population of the rare Nigerian-Cameroon chimpanzee (*Pan troglodytes ellioti*) in Ngel Nyaki Forest Reserve, Nigeria. *American Journal of Primatology* **77**(1): 86–97

Earnhardt, J.M., Ross, S.R., Lonsdorf, E.V. and Pusey, A.E. 2003. A demographic comparison of wild chimpanzees from Gombe and a managed population from North American zoos. *American Journal of Primatology* **60,** Supplement 1: 62-63.

EAZWV. 2002. Recommendations for the application of Annex C to Council Directive 92/65 ("BALAI") as amended by Council Regulation (EC) No 1282/2002 of 15 July 2002 (OJ L 187/3) in approved zoos.

EAZWV. 2004. Recommendations for Testing Procedures and Movement Protocols for Zoo Animals between Zoos of E.U. Member states (includes reference material of the AAZV)

EAZWV-IDWG (Infectious Disease Working Group of the European Association of Zoo- and Wildlife Veterinarians). 2004. IDWG-Transmissible Disease Handbook, 2nd edition

EAZWV-IDWG (Infectious Disease Working Group of the European Association of Zoo- and Wildlife

Veterinarians). 2018. Transmissible Disease Handbook. https://www.eazwv.org/general/custom.asp?page=inf_handbook
Edwards, D.P., Sloan, S., Weng, L., Dirks, P., Sayer, J. and Laurance, W.F. 2014. Mining and the African environment. *Conservation Letters* **7**(3): 302-311.
Elder, J. H.1938. The time of ovulation in chimpanzees. **Yale Journal of Biological Medicine 10**: 347-364.
Ely, J., Zavaskis, T., Lammey, M. and Lee, D. 2011. Blood pressure reference intervals for healthy adult chimpanzees (*Pan troglodytes*). *Journal of Medical Primatology.* **40**(3): 171-80.
Ely, J., Zavaskis, T. and Lammey, M.L. 2013. Hypertension increases with aging and obesity in chimpanzees (*Pan troglodytes*). *Zoo Biology* **32**(1): 79–87.
Farmer, H., Plowman, A., Green, K. and Taylor, L. 2010. Should zoo foods be chopped? Conference paper: ABWAK Symposium, Port Lympne Wild Animal Park.
Fernandez, E.J., Tamborski, M.A., Pickens, S.R. and, Timberlake, W. 2009. Animal–visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science* **120:** 1–8.
Fidgett, A., Bishop, J., Hosey, G. and Plowman, A. 2013. Handbook of Zoo Research, Guidelines for Conducting Research in Zoos. London. BIAZA.
Findley, E. R. 2002. The Effects of Enclosure Type on Aggressive Behavior in Captive Chimpanzees, Inquiry: *The University of Arkansas Undergraduate Research Journal:* **3**(9). Available at: http://scholarworks.uark.edu/inquiry/vol3/iss1/9
Fish, W.R., Young, W.C. and, Dorfman, R.I. 1941. Excretion of estrogenic and androgenic substances by female and male chimpanzees with known mating behavior records. *Endocrinology* **28:** 585-592.
Fisken, F.A., Carlsen, F., Elder, M., de Jongh, T., Pereboom, J. J. M., Pohl, B., Rietkerk, F., Ross, S. R. and Taniguchi, A. 2018. Global population records and managed programme updates for the great apes: a short report. *International Zoo Yearbook* **52:** 212-226.
Fouts, R.S. 1998. On the psychological well-being of chimpanzees. *Journal of Applied Animal Welfare Science* **1:** 65–73.
Fowler, M. E. and Miller, E. (eds.). 2003, 2007, 2010, 2014. Zoo and Wild Animal Medicine. 5th-8th Ed. Elsevier Saunders, St. Louis, Missouri.
Frandsen, P., Fontsere, C., Nielsen, S. V., Hanghøj, K., Castejon-Fernandez, N., Lizano, E., Hughes, D., Hernandez-Rodriguez, J., Korneliussen, T. S., Carlsen, F., Siegismund, H. R., Mailund, T., Marques-Bonet, T. & Hvilsom, C. (2020). Targeted conservation genetics of the endangered chimpanzee. *Heredity*, ***125***(1-2): 15-27. https://doi.org/10.1038/s41437-020-0313-0
Fraser, D. 2009. Assessing Animal Welfare: Different Philosophies, Different Scientific Approaches. *Zoo Biology* **28**: 507-518.
Fritz, J. and Howell, S. 2001 Captive Chimpanzee Social Group Formation. In: Brent, L. 2001, The care and management of captive chimpanzees: 173-204. American Society of Primatologists. San Antonio, Texas.
Fulk, R., and Garland, C. (eds.). 1992. The care and management of chimpanzees (*Pan troglodytes*) in captive environments. A husbandry manual developed for the chimpanzee species survival plan. Asheboro (NC): North Carolina Zoological Society.
Fünfstück, T., Arandjelovic, M., Morgan, D.B., Sanz, C., Olson, S.H., Cameron, K., Ondzie, A., Peeters, M. and Vigilant, L. 2015. The sampling scheme matters: *Pan troglodytes troglodytes* and *P. t. schweinfurthii* are characterized by clinal genetic variation rather than a strong subspecies break. *American Journal of Physical Anthropology* **156:** 181–191.
Furuichi, T. 2009. Factors underlying party size differences between chimpanzees and bonobos: a review and hypotheses for future study**.** *Primates* **50:** 197–209.
Gagneux, P., Boesch, C. and Woodruff, D. S. 1999. Female reproductive strategies, paternity and community structure in wild West African chimpanzees. *Animal Behaviour* **57(**1): 19-32.
Gaspar, A.D. 1996. Behavioral changes in Lisboa Zoo chimpanzees after social housing: The compared effects of physical environment, enrichment, and increased social experience. *Chimpanzoo Conference Proceedings:* 19–32.
Gilardi, K.V., Gillespie, T.R., Leendertz, F.H., Macfie, E.J., Travis, D.A., Whittier, C.A. and Williamson, E.A. 2015. Best Practice Guidelines for Health Monitoring and Disease Control in Great Ape Populations. IUCN SSC Primate Specialist Group, Gland, Switzerland

Gilby, I. 2006. Meat sharing among the Gombe chimpanzees: harassment and reciprocal exchange. *Animal Behaviour* **71:** 953-963.
Gilby, I. C., and Wrangham, R. W. 2007. Risk-prone hunting by chimpanzees (*Pan troglodytes schweinfurthii*) increases during periods of high diet quality. *Behavioral Ecology and Sociobiology*, **61:** 1771-1779.
Gilby, I. C., Eberly, L. E., and Wrangham, R. W. 2008. Economic profitability of social predation among wild chimpanzees: individual variation promotes cooperation. *Animal Behaviour* **75:** 351-360.
Gilby, I. C., Emery Thompson, M., Ruane, J. D. and Wrangham, R. 2010. No evidence of short-term exchange of meat for sex among chimpanzees. *Journal of Human Evolution*, **59:** 44-53.
Gilby, I., Eberly, L., Pintea, L., and Pusey, A. 2006. Ecological and social influences on the hunting behaviour of wild chimpanzees, *Pan troglodytes schweinfurthii*. *Animal Behaviour* **72:** 169-180.
Gippoliti, S. 2000. Orang-utans in zoos: husbandry, welfare and management in an atypical arboreal solitary mammal. *International. Zoo News* **47**(6): 356-368
Gomes, C. M., and Boesch, C. 2009. Wild Chimpanzees Exchange Meat for Sex on a Long-Term Basis. *PLoS ONE* **4:** 16-18
Gomes, C. M. and Boesch, C. 2011. Reciprocity and trades in wild West African chimpanzees. *Behavioral Ecology and Sociobiology*: 2183-2196.
Gonder, M. K, Oates, J. F., Disotell, T. R., Forstner, M. R., Morales, J. C. and Melnick, D. J. 1997. A new West African Chimpanzee subspecies? *Nature* **388:** 337.
Gonder, M. K., Disotell, T. R. and Oates J. F. 2006. New Genetic Evidence on the Evolution of Chimpanzee Populations and Implications for Taxonomy. *International Journal of Primatology* **27**(4): 1103-1127.
Goodall, J. 1983. Population dynamics during a 15 year period in one community of free-living chimpanzees in the Gombe National Park, Tanzania. *Zeitschrift für Tierpsychologie* **61**:1-60
Goodall, J. 1986. *The Chimpanzees of Gombe. Patterns of Behavior.* Cambridge, MA: Harvard University Press.
Graham, C. E. 1981**.** Menstrual cycle of great apes. In: Graham CE. (ed.), Reproductive biology of the great apes: comparative and biomedical perspectives. New York: Academic Press: 1-43.
Graham, C. E., Collins, D. C., Robinson, H. and Preedy, J. R. K. 1972. Urinary levels of estrogen and pregnanediol and plasma levels of progesterone during the menstrual cycle of the chimpanzee: relationship to the sexual swelling. *Endocrinology* **91:** 13-24.
GRASP & IUCN. 2018. Report to the CITES Standing Committee on the Status of Great Apes. United Nations Environment Programme Great Apes Survival Partnership, Nairobi, and International Union for Conservation of Nature, Gland.
Greengrass, E. J. 2009. Chimpanzees are close to extinction in southwest Nigeria. *Primate Conservation*, **24:** 77-83.
Greengrass, E. J. and Maisels, F. 2007. Conservation of the Nigerian-Cameroon chimpanzee *P. t. vellerosus* (and other mammals) in and around the Banyang-Mbo Wildlife Sanctuary, South-west Province, Cameroon. *Wildlife Conservation Society*, Yaoundé, Cameroon.
Groves, C.P. 2001. Primate taxonomy. Smithsonian Institution Press. Washington D.C.
Groves, C.P. 2005. Geographic variation within eastern chimpanzees (*Pan troglodytes cf schweinfurhtii*, Giglioli, 1872). *Australasian Primatology* **17**(2): 19-46
Groves, C.P. 2018. The latest thinking about the taxonomy of great apes. *International. Zoo Yearbook.* **52**: 16-24
Hanamura, S., Kiyono, M., Nakamura, M., Sakamaki, T., Itoh, N., Zamma, K., Kitopeni, R., Matumula, M. and Nishida, T. 2006. A new code of observation employed at Mahale: prevention against a flu-like disease. *Pan Africa News* **13**(2): 13-16.
Hansen, B.C. 2004. Primate animal models of type 2 diabetes. In: LeRoith, Olefsky, Taylor. *Diabetes Mellitus: A Fundamental and Clinical Text***:** 1060-1074. J.B. Lippincott. Philadelphia.
Herrelko, E. S., Vick, S. J. and Buchanan-Smith, H. M. 2012. Cognitive research in zoo-housed chimpanzees: influence of personality and impact on welfare. *American Journal of Primatology* **74**(9):828-40.
Herrelko, E.S., Buchanan-Smith, H.M. and Vick, S.J. 2015. Perception of available space during chimpanzee introductions: number of accessible areas is more important than enclosure size. *Zoo Biology* **34:** 397-405.
Heuschele, W.P. 1995 Use of disinfectants in zoos and game parks. *Rev Sci Tech.* **14**(2):447-54

Hicks, C., Darby, L., Hart, J., Swinkels, J., January, N. and Menken, S. 2010. Trade in orphans and bushmeat threatens one of the Democratic Republic of the Congo's most important populations of eastern chimpanzees (*Pan troglodytes schweinfurthii*). *African Primates* **7**, 1–18.
Hicks, T.C., Tranquilli, S., Kühl, H.S., Campbell, G., Swinkels, J., Darby, L., Boesch, C., Hart, J. and Menken, S.B. 2014. Absence of evidence is not evidence of absence: discovery of a large, continuous population of *Pan troglodytes schweinfurthii* in the Central Uele region of northern DRC. *Biological Conservation* **171:** 107–113.
Hill, S.P. 2018. Regurgitation and reingestion (R/R) in great apes: a review of current knowledge. *International. Zoo Yearbook.* **52:** 62-78.
Hill, S.P., Broom, D.M. 2009. Measuring zoo animal welfare: theory and practice. *Zoo Biology* **28:** 531–544.
Hill, W. C. O. 1969. The Nomenclature, Taxonomy and Distribution of Chimpanzees. *The Chimpanzee* **1:** 22-49. Karger, Basel/New York.
Hockings, K. J., Humle, T., Anderson, J. R., Biro, D., Sousa, C., Ohashi, G., and Matsuzawa, T. 2007. Chimpanzees share forbidden fruit. *PloS ONE*, **2:** e886.
Hockings, K., Anderson, J. and Matsuzawa, T. 2009. Use of wild and cultivated foods by chimps as Bossou, republic of guinea: feeding dynamics in a human influenced environment. *American Journal of Primatology* **71:** 636-646.
Hohmann, G., Potts, K., N'Guessan, A., Fowler, A., Mundry, R., Ganzhorn, J. and Ortmann, S. 2010. Plant foods consumed by Pan: Exploring the variation of nutritional ecology across Africa. *American Journal of Physical Anthropology* **141:** 476-485.
Hosey, G., Melfi, V. and Pankhurst, S. 2013. *Zoo Animals: Behaviour, Management and Welfare.* Oxford: Oxford University Press.
Howell, S., Hoffman, K., Bartel, L., Schwandt, M., Morris, J. and Fritz, J. 2003. Normal hematologic and Serum clinical chemistry values for captive chimpanzees (*Pan troglodytes*). In: *Comparative Medicine* **53:** 413-423
Howell, S., Mittra, E., Fritz, J. and Baron, J. 1997. The provision of cage furnishings as environmental enrichment at the primate foundation of Arizona. *The Newsletter* **9:** 1–5.
Huffman, M.A. 1997. Current evidence for self-medication in primates: a multidisciplinary perspective. *Yearbook of Physical Anthropology* **40:** 171–200.
Huffman, M.A. and Caton, J.M. 2001. Self-induced increase of gut motility and the control of parasitic infections in wild chimpanzees. *International Journal of Primatology* **22:** 329–346.
Huffman, M.A., Koshimizu, K. and Ohigashi, H. 1996. Ethnobotany and zoopharmacognosy of *Vernonia amygdalina*, a medicinal plant used by humans and chimpanzees. In: P.D.S. Caligari, D.J.N. Hind (Eds.), *Compositae: Biology and Utilization* ***2***. Kew (UK): Royal Botanical Gardens: 351–360.
Huffman, M. A., Spiezio, C., Sgaravatti, A. and Leca, J. B. 2010. Leaf swallowing behavior in chimpanzees (*Pan troglodytes*): biased learning and the emergence of group level cultural differences. *Animal Cognition* **13:** 871-880.
Huffman, M.A. and Wrangham, R.W. 1994. The diversity of medicinal plant use by chimpanzees in the wild. In: R.W. Wrangham, W.C. McGrew, F.B. de Waal, P.G. Heltne (Eds.), *Chimpanzee Cultures*. Cambridge (MA): Harvard University Press: 129–148.
Humle, T. 2011. The 2003 epidemic of a flu-like respiratory disease at Bossou. In: T. Matsuzawa, T. Humle and Y. Sugiyama (eds), *Chimpanzees of Bossou and Nimba:* 325–333. Springer Verlag, Tokyo.
Humle, T. and Matsuzawa, T. 2002. Ant-dipping among the chimpanzees of Bossou, Guinea, and some comparisons with other sites. *American Journal of Primatology*, **58:** 133-148.
Humle, T., Maisels, F., Oates, J.F., Plumptre, A. and Williamson, E.A. 2016. *Pan troglodytes*. (Errata version published in 2016) The IUCN Red List of Threatened Species 2016: e.T15933A102326672. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T15933A17964454.en.
Hunt, K. D. 1989. Positional behavior in *Pan troglodytes* at the Mahale Mountains and Gombe Stream National Parks, Tanzania. Ph.D. diss., Univ. of Michigan, Ann Arbor. Univ. Microfilms.
Hvilsom, C., Frandsen, P., Børsting, C., Carlsen, F., Sallé, B., Simonsen, B. T. and Siegismund, H. R. 2013. Understanding geographic origins and history of admixture among chimpanzees in European zoos with implications for future breeding programmes. *Heredity* **110:** 586-593.
IDWG. 2000. Guidelines for comprehensive ape health monitoring program.

Inoue-Nakamura, N. and Matsuzawa, T. 1997. Development of stone tool use by wild chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology* **111**(2): 159–73.

Isabirye-Basuta, G. 1989. Feeding ecology of chimpanzees in the Kibale Forest, Uganda. In: P.G. Heltne, L.A. Marquardt (Eds.), *Understanding Chimpanzees*, Cambridge, Massachusetts: Harvard University Press: 116-127.

Itoh, N., and Nishida, T. 2007. Chimpanzee grouping patterns and food availability in Mahale Mountains National Park, Tanzania. *Primates*, **48:** 87-96.

IUCN/SSC 2014**.** Guidelines on the use of *ex situ* management for species conservation. Version 2.0 Gland, Switzerland: IUCN Species Survival Commission.

IUCN 2014. Regional Action Plan for the Conservation of Western Lowland Gorillas and Central Chimpanzees 2015–2025. Gland, Switzerland: IUCN SSC Primate Specialist Group. 56 pp. http://static1.1.sqspcdn.com/static/f/1200343/26274825/1433108664180/WEA_English_corrected.pdf?token=4b8HHq57cefZ2eO9ySkXJhu0waw%3D

Jacobson, S. L., Hopper, L. M., Shender, M. A., Ross, S. R., Leahy, M. and, McNernie, J. 2017. Zoo visitors' perceptions *of* chimpanzee welfare are not affected *by the* provision *of* artificial environmental enrichment devices in *a* naturalistic exhibit. *JZAR* **5:** 56-61.

Jones, C., Jones, C. A., Jones, J. K. J., and Wilson, D. E. 1996. *Pan troglodytes*. *Mammalian Species* **529:** 1-9.

Junge, R., Gannon, F. H., Porton, I., Mcalister, W. and Whyte, M. P. 2000. Management and prevention of vitamin D deficiency rickets in captive-born juvenile chimpanzees (*Pan troglodytes*). *Journal of Zoo and Wildlife Medicine* **31** (3): 361-369.

Kazzam, E., Ghurbana, B., Obineche, E. and Nicholls, M. 2005. Hypertension – still and important cause of heart failure? *Journal of Human Hypertension* **19**, 267-275.

Kessel, A. L. and Brent, L. 1998. Cage toys reduce abnormal behavior in individually housed pigtail macaques. *Journal of Applied Animal Welfare Science* **1:** 227-234.

Kishimoto, T., Ando, J., Tatara, S., Yamada, N., Konishi, K., Kimura, N., Fukumori, A. and Tomonaga, M. 2014. Alloparenting for chimpanzee twins. *Nature Scientific Reports* **4**, 6306, DOI 10. 1038/srep06306

Kormos, R., Boesch, C., Bakarr, M. I. and Butinsky, T. M. (eds). 2003. *Regional Action Plan for the Conservation of Chimpanzees in West Africa*. IUCN/SSC Primate Specialist Group, IUCN, Gland, Switzerland.

Korneliussen, T., Carlsen, F., Siegismund, H.R., Mailund, T., Marques-Bonet. T. and Hvilsom C. In prep. Targeted genetic conservation of the endangered chimpanzee.

Köndgen, S., Kühl, H., N'Goran, P. K., Walsh, P. D., Schenk, S., Ernst, N., Biek, R., Formenty, P., Maetz-Rensing, K., Schweiger, B., Junglen, S., Ellerbrok, H., Nitsche, A., Briese, T., Lipkin, W. I., Pauli, G., Boesch, C. and Leendertz, F. H. 2008. Pandemic human viruses cause decline of endangered great apes. *Current Biology* **18:** 260–264.

Kramer, L. 1997. Bonobo health Management. In: Mills, J., Reinartz, G., de Bois, H., van Elsacker, L. and van Puijenbroeck, B. (eds). The care and management of bonobos in captive environments. Zoological Society of Milwaukee County, Milwaukee, WI.

Krebs, B. L., Marrin, D., Phelps, A., Krol, L. and Watters, J. V. 2018. Managing Aged Animals in Zoos to Promote Positive Welfare: A Review and Future Directions. *Animals* **8:** 116.

Kusonoki, H., Daimaru, H., Minami, S., Nishimoto, S., Yamane, K. and Fukumoto, Y. 2001. Birth of a chimpanzee (*Pan troglodytes*) after artificial insemination with cryopreserved epididymal spermatozoa collected postmortem. *Zoo Biology* **20:**135-143.

Kutska, D. 2009. Variation in visitor perceptions of a polar bear enclosure based on the presence of natural vs. un-natural enrichment items. *Zoo Biology* **28:** 292–306.

Kühl, H., Maisels, F., Ancrenaz, M. and Williamson, E.A. 2008. Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations. IUCN SSC Primate Specialist Group, Gland, Switzerland. http://static1.1.sqspcdn.com/static/f/1200343/20457425/1348938386080/BP.surveys.pdf?token=mvdWyUbv3q7jzwWdzuT9Go0r2vY%3D

Kühl, H. S., Sop, T., Williamson, E. A., Mundry, R., Brugière, D., Campbell, G., Cohen, H., Danquah, E., Ginn, L., Herbinger, I., Jones, S., Junker, J., Kormos, R., Kouakou, C. Y., N'Goran, P. K., Normand, E., Shutt-Phillips, K., Tickle, A., Vendras, E., Welsh, A., Wessling, E. G. and Boesch, C. 2017. The critically endangered western chimpanzee declines by 80%. *American Journal of Primatology.* **79**(9). https://doi.org/10.1002/ajp.22681

Kuhlwilm, M., de Manuel, M., Nater, A., Greminger, M.P., Krützen, M. and Marques-Bonet, T. 2016. Evolution and demography of the great apes. *Current Opinion in Genetics & Development* **41**: 124-129

Lacreuse, A., Chennareddi, L., Gould, K. G., Hawkes, K., Wijayawardana, A. R., Chen, J., Easley, K. A., and Herndon, J. G. 2008. Menstrual Cycles Continue into Advanced Old Age in the Common Chimpanzee (*Pan troglodytes*). *Biology of reproduction* **79:** 407-412

Lambeth, S. P. and Bloomsmith, M. A. 1994. A Grass Foraging Device for Captive Chimpanzees (*Pan troglodytes*). *Animal Welfare* **3:** 13-24.

Lambeth, S. P., Hau, J., Perlman, J. E., Martino, M. and Schapiro, S. J. 2006.Positive reinforcement training affects hematologic and serum chemistry values in captive chimpanzees (*Pan troglodytes*). *American Journal of Primatology.* **68:** 245–256.

Langergraber, K. E., Boesch, C., Inoue, E., Inoue-Murayama, M., Mitani, J. C., Nishida, T., Pusey, A., Reynolds, V., Schubert, G., Wrangham, R. W., Wroblewski, E. and Vigilant, L. 2011**.** Genetic and 'cultural' similarity in wild chimpanzees. *Proc. R. Soc. B*. **278:** 408-416.

Langergraber, K. E., Prüfer, K., Rowney, C., Boesch, C., Crockford, C., Fawcett, K., Inoue, E., Inoue-Muruyama, M., Mitani, J. C., Muller, M. N., Robbins, M. M., Schubert, G., Stoinski, T. S., Viola, B., Watts, D., Wittig, R. M., Wrangham, R. W., Zuberbühler, K., Pääbo, S. and Vigilant, L. 2012. Human and great ape divergence times. *Proc. Natl. Acad. Sci. USA* **109:** 15716-15721

Lanjouw, A. 2014. Mining/oil extraction and ape populations and habitats. In: Arcus Foundation (ed.), *State of the Apes 2013: Extractive Industries and Ape Conservation*: 127–161. Cambridge University Press, Cambridge, UK.

Laporte, N. T., Stabach, J. A., Grosch, R., Lin, T. S. and Goetz, S. J. 2007. Expansion of industrial logging in Central Africa. *Science* **316:** 1451

Laurance, W. F., Clements, G. R., Sloan, S., O'Connell, C. S., Mueller, N. D., Goosem, M., Venter, O., Edwards, D. P., Phalan, B., Balmford, A., Van Der Ree, R. and Arrea, I. B. 2014. A global strategy for road building. *Nature* **513:** 229–232.

Laurance, W. F., Sloan, S., Weng, L., and Sayer, J. A. (2015). Estimating the environmental costs of Africa's massive 'development corridors. *Current Biology*, **25**, 3202– 3208.

Laurence, H., Kumar, S., Owston, M., Lanford, R., Hubbard, G. and Dick Jr. E. 2017. Natural mortality and cause of death analysis of the captive chimpanzee (*Pan troglodytes)*: A 35-year review. *Journal of Medical Primatology* **46**(3): 106-115.

Leendertz, F. H., Pauli, G., Maetz-Rensing, K., Boardman, W. and Nunn, C., Ellerbrok, H., Junglen, S. and Boesch, C. 2006. Pathogens as drivers of population declines: the importance of systematic monitoring in great apes and other threatened mammals. *Biological Conservation* **131**: 325–337.

Lewis, J. 2003. Preventive health measures for primates and keeping staff in British and Irish zoological collections. International Zoo Veterinary Group A report to the British and Irish Primate Taxon Advisory Group (B&I PTAG), London, Federation of Zoos

Locke, D.P., Hillier, L.W., Warren., W.C., Worley, K.C., Nazareth, L.V., Muzny, D.M., Yang, S_P., Wang, Z., Chinwalla, A.T., Minx, P., Mitreva, M., Cook, L., Delehaunty, K.D., Fronick, C., Schmidt, H., Fulton, L.A., Fulton, R.S., Nelson, J.O., Magrini, V., Pohl, C., Graves, T.A., Markovic, C., Cree, A., Dinh, H.H., Hume, J., Kovar, C.L., Fowler, G.R., Lunter, G., Meader, S., Heger, A., Ponting, C.P., Marques-Bonet, T., Alkan, C., Chen, L., Cheng, Z., Flicek, P., Ma, J., Raney, B., Suh, B., Burhans, R., Herrero, J., Haussler, D., Faria, R., Fernando, O., Darré, F., Farré, D., Gazave, E., Oliva, M., Navarro, A., Roberto, R., Capozzi, O., Archidiacono, N., Della Valle, G., Purgato, S., Rocchi, M., Konkel, M.K., Walker, J.A., Ullmer, B., Batzer, M.A., Smit, A.F.A., Hubley, R., Casola, C., Schrider, D.R., Hahn, M.W., Quesada, V., Puenter, X.S., Ordoñez, G.R., López-Otín, C., Vinar, T., Brejova, B., Ratan, A., Harris, R.S., Miller, W., Kosiol, C., Lawson, H.A., Taliwal, V., Martins, A.L., Siepel, A., RoyChoudhury, A., Ma, X., Degenhardt, J., Bustamante, C.D., Gutenkunst, R.N., Mailund, T., Dutheil, J.Y., Hobolth, A., Schierup, M.H., Chemnick, L., Ryder, O.A., Yoshinaga, Y., de Jong, P.J., Weinstock, G.M., rogers, J., Mardis, E., Gibbs, R.A. and Wilson, R.K. 2011. Comparative and demographic analysis of orangutan genomes. *Nature* **469** (7331): 529-533.

Lonsdorf, E. 2005. Sex differences in the development of termite-fishing skills in the wild chimpanzees, *Pan troglodytes schweinfurthii*, of Gombe National Park, Tanzania. *Animal Behaviour*, **70:** 673-683.

Loomis, M. R. 1992. Health. In: The care and management of chimpanzees in captive environments. A husbandry manual developed for the Chimpanzee Species Survival Plan. SSP.

Lowe, A. E., Hobaiter, C. and Newton-Fischer, N. E., 2018. Countering infanticide: Chimpanzee mothers are sensitive to the relative risks posed by males on different rank trajectories. *American Journal of Physical Anthropology* **168**(1): 3-9

Luncz, L. and Boesch, C. 2015. The extent of cultural variation between adjacent chimpanzee (*Pan troglodytes verus*) communities; A microecological approach. *American Journal of Physical Anthropology*. **156:** 67-75.

Lüders, I. and López Béjar, M. 2018 "Great Ape Gamete Recovery Initiative" (EAZA Great Ape TAG).

Lycett, S. J., Collard, M. and McGrew, W. C. 2010. Are behavioral differences among wild chimpanzee communities genetic or cultural? An assessment using tool-use data and phylogenetic methods. *American Journal of Physical Anthropology*, **142:** 461-467.

Maisels, F., Ella Akou, M., Douckaga, M. and Moundounga, A. 2004. Mwagne National Park, Gabon: large mammals and human impact. WCS/WWF Gabon.

Maisels, F., Strindberg, S., Kiminou, F., Ndzai, C., Ngounga, R. *et al.* 2013. Wildlife and Human Impact Survey 2012, and monitoring 2005–2008–2012. Odzala-Kokoua National Park, Republic of Congo. Fondation Odzala-Kokoua and Wildlife Conservation Society, Brazzaville, Congo.

Maple, T. L. 1979. Great apes in captivity: The good, the bad, and the ugly. In: J. Erwin, T.L. Maple, G. Mitchell (Eds.), *Captivity and behavior: Primates in breeding colonies, laboratories and zoos*. New York: Van Nostrand Reinhold: 239–272.

Markowitz, H. 2011. Enriching Animal Lives. Pacifica, California: Mauka Press.

Marques-Bonet, T. and Hvilsom, C. 2018. Genomic variation of the great apes and the application to conservation. *International Zoo Yearbook,* **52:** 25-33.

Marsden, S. B., Marsden, D., and Thompson, M. E. 2006. Demographic and Female Life History Parameters of Free-Ranging Chimpanzees at the Chimpanzee Rehabilitation Project, River Gambia National Park. *International Journal of Primatology*, **27:** 391-410.

Martin, D. E., Graham, C. E. and Gould K. G. 1978. Successful artificial insemination in the chimpanzee. Symposia of the zoological society of London **43:** 249-260.

Matsubayashi, K., Kumazaki, K. and Kamanaka, Y. 1985. Three successful cases of artificial insemination in chimpanzees. *Jikken Dobutsu* **34** (2): 203-206

Matsumoto-Oda, A., Hosaka, K., Huffman, M. A. and Kawanaka, K. 1998. Factors Affecting Party Size in Chimpanzees of the Mahale Mountains. *International Journal of Primatology*, **19:** 999-1011.

Matsumoto-Oda, A. 1999. Female choice in the opportunistic mating of wild chimpanzees (*Pan troglodytes schweinfurthii*) at Mahale. Behavioral Ecology and Sociobiology **46**(4): 258–266.

Matsumoto, T. And Hayaki, H. 2015. Development and growth with special reference to mother-infant relationships. Mahale chimpanzees: 50 years of research: 313-325. Cambridge University Press, Cambridge.

Matsuzawa, T. 2011. Stone tools for nut-cracking. In: T. Matsuzawa, T. Humle, Y. Sugiyama, (Eds.), The chimpanzees of Bossou and Nimba. Springer: 73–84.

Matsuzawa, T., Humle, T. & Sugiyama, Y. (Eds) 2011. The chimpanzees of Bossou and Nimba. Springer.

McArthur, J. W., Beitins, I. Z., Gorman, A., Collins, D. C., Preedy, J. R. K. and Graham, C. E. 1981. The interrelationships between sex skin swelling and urinary excretion of LH, estrone, and pregnanediol by the cycling female chimpanzee. *American Journal of Primatology* **1:** 265-270.

McDonald, S. 1994. The Detroit Zoo chimpanzees *Pan troglodytes*: Exhibit design, group composition, and the process of group formation. *International Zoo Yearbook* **33:** 235–247

McGrew, W. 1992. Chimpanzee Material Culture – Implications for Human Evolution. Cambridge University Press.

McGrew, W., Baldwin, P. and Tutin, C. 1988. Diet of Wild Chimpanzees (*Pan troglodytes verus*) at Mt Assirik, Senegal: 1. Composition. *American Journal of Primatology* **16**(3): 213–226.

McNary, J. K. 1992**.** Integration of chimpanzees (*Pan troglodytes*) in captivity. In: Fulk R, Garland C. (eds.). The care and management of chimpanzees (*Pan troglodytes*) in captive environments. A husbandry manual

developed for the chimpanzee species survival plan. Asheboro (NC): North Carolina Zoological Society: 88-92.
McPhee, M. E., Foster, J. S., Sevenich, M. and Saunders, C. D. 1998. Public perceptions of behavioral enrichment: Assumptions gone awry. *Zoo Biology* **17:** 525–534.
McTighe, M., Hansen, B., Ely, J. and Lee, D. 2011. Determination of Hemoglobin A1c and Fasting Blood Glucose Reference Intervals in Captive Chimpanzees (*Pan troglodytes). Journal of the American Association for Laboratory Animal Science* **50**(2): 165-170.
Melis, S., Schauvliege, S., van Bolhuis, H., Hoyer, M. and Gasthuys, F. 2012 Chemical immobilization of chimpanzees (*Pan troglodytes*) using a combination of detomidine and ketamine. *Veterinary Anaesthesia and Analgesia* **39**: 520–528
Mellor, D. J., Hunt, S. and Gusset, M. Eds, 2015. Caring for Wildlife: The World Zoo and Aquarium Animal Welfare Strategy. Gland: WAZA Executive Office, 87 pp.
Mellor, D. J. and Beausoleil, N. J., 2015. Extending the 'Five Domains' model for animal welfare assessment to incorporate positive welfare states. *Animal Welfare*. **24**.
Mellor, D. J., Beausoleil, N. J., Littlewood, K. E., McLean, A. N., McGreevy, P. D., Jones, B. and Wilkins, C., 2020. The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare. *Animals*. **10**(10): 1870.
Milton, K. and Demment, M. 1989. Features of meat digestion by captive chimpanzees (*Pan troglodytes*). *American Journal of Primatology* **18**(1): 45–52.
Mitani, J.C. 2006. Demographic influences on the behavior of chimpanzees. *Primates* **47**(1): 6-13.
Mitani, J. C. and Amsler, S. J. (2003). Social and spatial aspects of male subgrouping in a community of wild chimpanzees. *Behaviour* **140:** 869-884
Mitani, J. C., and Watts, D. P. 2001. Why do chimpanzees hunt and share meat? *Animal Behaviour*, **61:** 915-924.
Mitani, J. C., Watts, D. P. and Muller M. N. 2002. Recent developments in the study of wild chimpanzee behavior. *Evolutionary Anthropology* **11:** 9-25.
Möbius, Y., Boesch, C., Koops, K., Matsuzawa, T., and Humle, T. 2008. Cultural differences in army ant predation by West African chimpanzees? A comparative study of microecological variables. *Animal Behaviour*, **76:** 37-45.
Moore, J., Black, H., Hernandez-Aguilar, A., Idani, G., Piel, A. and Stewart, F. 2017. Chimpanzee vertebrate consumption: Savanna and forest chimps compared. *Journal of Human Evolution* **112:** 30-40.
Morgan, B., Adeleke, A., Bassey, T., Bergl, R., Dunn, A., Fotso, R., Gadsby, E., Gonder, K., Greengrass, E., Koulagna, D. K., Mbah, G., Nicholas, A., Oates, J., Omeni, F., Saidu, Y., Sommer, V., Sunderland-Groves, J., Tiebou, J. and Williamson, E. A. 2011. Regional Action Plan for the Conservation of the Nigeria-Cameroon Chimpanzee (*Pan troglodytes ellioti*). IUCN/SSC Primate Specialist Group and Zoological Society of San Diego, San Diego.
Morgan, D. & Sanz, C. 2007. Best Practice Guidelines for Reducing the Impact of Commercial Logging on Great Apes in Western Equatorial Africa. IUCN SSC Primate Specialist Group, Gland, Switzerland. http://static1.1.sqspcdn.com/static/f/1200343/20457622/1348940304807/BP.logging.pdf?token=jrL7%2BQVqc6d%2BJimROaXSTYTCojg%3D
Morgan, B.J., Adeleke, A., Bassey, T., Bergl, R., Dunn, A. and Fotso, R. 2011. Regional Action Plan for the Conservation of the Nigeria-Cameroon Chimpanzee (Pan troglodytes ellioti). IUCN/SSC Primate Specialist Group and Zoological Society of San Diego. http://static1.1.sqspcdn.com/static/f/1200343/20456353/1348922758247/NCCAP.pdf?token=ofEEn5%2BmpWARWbOgibXn0E6GKGM%3D
Morgan, D., Sanz, C., Greer, D., Rayden, T., Maisels, F. & Williamson, E.A. 2013. Great Apes and FSC: Implementing 'Ape Friendly' Practices in Central Africa's Logging Concessions. IUCN SSC Primate Specialist Group, Gland, Switzerland. http://static1.1.sqspcdn.com/static/f/1200343/22448953/1365973134023/Great_apes_and_FSC.pdf?token=5oUg2iH97tiJMbyyDuIWyv5DYl4%3D
Morgan, K. N., Tromborg, C. T. 2007. Sources of Stress in Captivity. *Applied Animal Behaviour Science*, **102:** 262-302.

Morin, P. A., Moore, K. J., Chakraborty, R., Jin, L., Goodall, J. and, Woodruff, D. S. 1994. Kin selection, social structure, gene flow and the evolution of chimpanzees. *Science* **265**: 1193-1201

Moscovice, L. R., Issa, M. H., Petrzelkova, K. J., Keuler, N. S., Snowdon, C. T., Huffman, M. A., Island, R., Park, N., and Republic, C. 2007. Fruit Availability, Chimpanzee Diet, and Grouping Patterns on Rubondo Island, Tanzania. **502:** 487-502.

Mulder, I., van der Meer, R., de Vries, H. and Sterck, R. 2016. The relationship between diet change and regurgitation and reingestion in captive chimpanzees. *Journal of Zoo and Aquarium Research,* **4**(4): 196–201.

Muller, M.N. 2002. Agonistic relations among Kanyawara chimpanzees. In: *Behavioural diversity in chimpanzees and bonobos.* Boesch, C., Hohmann, G and Marchant, L.F. (eds.): 112-123. Cambridge University Press, Cambridge.

Muller, M. N., and Mitani, J. C. 2005. Conflict and Cooperation in Wild Chimpanzees. *Advances in the Study of Behavior* **35:** 275-331.

Murphy, H.W., Danforth, M.D. and Clyde, V.L. 2018: The great ape heart project. *International. Zoo Yearbook.* **52:** 103-112.

Nadler, R. D., Dahl, J. F., Collins, D. C. and Gould, K. G. 1994 Sexual behavior of chimpanzees (*Pan troglodytes*): Male versus female regulation. *Journal of Comparative Psychology* **108**(1): 58-67

Nadler, R. D., Graham, C. E., Gosselin, R. E. and Collins, D. C. 1985. Serum levels of gonadotrophins and gonadal steroids, including testosterone, during the menstrual cycle of the chimpanzee (*Pan troglodytes*). *American Journal of Primatology* **9:** 273-284.

Nakamura, M., Hosaka, K., Itoh, N. and Zamma, K. (Eds.) 2015. Mahale chimpanzees – 50 years of research. Cambridge University Press.

National Research Council 2003. Nutrient Requirements of non-human primates. The national academies press, Washington: USA.

Newton-Fisher, N.E. 2002. Ranging patterns of male chimpanzees in the Budongo forest, Uganda. In: *Behavioural diversity in chimpanzees and bonobos.* Boesch, C., Hohmann, G and Marchant, L.F. (eds.): 124-137. Cambridge University Press, Cambridge.

Newton-Fisher, N. E. 2003. The home range of the Sonso community of chimpanzees from the Budongo Forest, Uganda. *African Journal of Ecology* **41:** 150–156.

N'guessan, A., Ortmann, S. and Boesch, C. 2009. Daily energy balance and protein gain among *Pan troglodytes verus* in the Taï national park, Côte d'Ivoire. *International Journal of Primatology* **30:** 481-496.

Nishida, T. 1968 The social group of wild chimpanzees in the Mahale Mountains. *Primates* **9**: 167–224

Nishida, T. 1989. Social interactions between resident and immigrant female chimpanzees. In: *Understanding chimpanzees*, Heltne, P.G. and Marquardt, L. (eds): 68-89. Harvard University Press, Cambridge MA.

Nishida, T., Hiraiwa-Hasegawa, M., Hasegawa, T. And Takahata, Y. 1985. Group extinction and female transfer in wild chimpanzees in the Mahale National Park, Tanzania. *Zeitschrift für Tierpsychologie.* **67**: 284-301

Nishida, T., Corp, N., Hamai, M., Hasegawa, T., Hiraiwa-Hasegawa, M., Hosaka, K., Hunt, K. D., Itoh, N., Kawanaka, K., Matsumoto-Oda, A., Mitani, J. C., Nakamura, M., Norikoshi, K., Sakamaki, T., Turner, L., Uehara, S. and Zamma, K. 2003. Demography, female life history, and reproductive profiles among the chimpanzees of Mahale. *American Journal of Primatology* **59:** 99-121.

Nishida, T., Kano, T., Goodall, J., McGrew, W. C. and Nakamura, M. 1999. Ethogram and Ethnography of Mahale Chimpanzees. *Anthropological Science* **107**(2): 141-188

Nishida T, Kawanaka K. 1972. Inter-unit-group relationships among wild chimpanzees of the Mahali Mountains. *Kyoto University African Studies* **7**: 131–169.

Nishida, T., Takasaki, H., and Takahata, Y. (1990). Demography and reproductive profiles. In T. Nishida (Ed.), The chimpanzees of the Mahale mountains: Sexual and life history strategies: 63–97. Tokyo: *University of Tokyo Press*.

Nishida, T., Zamma, K., Matsusaka, T., Inaba, A.C. and McGrew, W. 2010. Chimpanzee behavior in the wild. Springer Nature.

Nishie, H. 2011. Natural history of *Camponotus* ant-fishing by the M group chimpanzees at the Mahale Mountains National Park, Tanzania. *Primates* **52:** 329-342.

Nishie, H. and Nakamura, M. 2017, A newborn infant chimpanzee snatched and cannibalized immediately after birth: Implications for "maternity leave" in wild chimpanzee. *American Journal of Physical Anthropology* **165:** 194–199.

Novak, M.A., O'Neill, P., Beckley, S.A. and, Suomi, S.J. 1994. Naturalistic environments for captive primates. In E.F. Gibbons, E.J. Wyers, E. Waters, E.W. Menzel (Eds.), *Naturalistic environments in captivity for animal behavior research.* Albany: State University of New York Press: 236–258.

Nowak, R. M. 1999. *Walker's Mammals of the World, Vol. 1.* 6th Ed. Baltimore: The Johns Hopkins University Press.

Nunamaker, E. A., Lee, D. R. and Lammey, M. L. 2012. Chronic diseases in captive geriatric female Chimpanzees (Pan troglodytes). *Comp Med.* **62(2):**131-136**.**

Oates, J. F. 2006. Is the chimpanzee, *Pan troglodytes*, an endangered species? It depends on what "endangered" means. *Primates*, **47:** 102-12.

Oates, J. F. 2011. Primates of West Africa. Conservation International

Oates, J. F., Tutin, C. E. G., Humle, T., Wilson, M. L., Baillie, J. E. M., Balmforth, Z., Blom, A., Boesch, C., Cox, D., Davenport, T., Dunn, A., Dupain, J., Duvall, C., Ellis, C. M., Farmer, K. H., Gatti, S., Greengrass, E., Hart, J., Herbinger, I., Hicks, C., Hunt, K. D., Kamenya, S., Maisels, F., Mitani, J. C., Moore, J., Morgan, B. J., Morgan, D. B., Nakamura, M., Nixon, S., Plumptre, A. J., Reynolds, V., Stokes, E. J., and Walsh, P. D. 2008. *Pan troglodytes*. In: IUCN Red List of Threatened Species. Version 2011.2, 4. IUCN.

Oates, J.F., Groves, C.P. and Jenkins P. D. 2009. The type locality of *Pan troglodyt*es *vellerosus* (Gray 1862) and implications for the nomenclature of West African chimpanzees. *Primates* **50:** 78-80.

Oftedal, O. T. and Allen, M. E. 1996. The feeding and nutrition of omnivores with emphasis on primates. In: Wild mammals in captivity, principles and techniques. Kleiman, D., Allen, M. E., Thompson, K. V. & Lumpkin, S. (Eds). University of Chicago Press.

O.I.E. International Animal Health Code 2019**.** Zoonoses transmissible from nonhuman primates. http://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_zoonoses_non_human_primate.pdf

O'Neil, P. 1989. A room with a view for captive primates: issues, goals, related research and strategies. In: The housing, care and psychological wellbeing of captive and laboratory primates. Segal, E.F., editor Park Ridge (NJ): *Noyes Publications*: 135-160.

Otali, E. and Gilchrist, J. S.2006. Why chimpanzee (*Pan troglodytes schweinfurthii*) mothers are less gregarious than nonmothers and males: The infant safety hypothesis. *Behavioral Ecology and Sociobiology* **59:** 561–570.

Pankhurst, S. J., Plumb, A. C. and Walter, O. (Eds.) 2008. Zoo Research Guidelines: Getting Zoo Research Published. London: BIAZA

Paquette, D., Prescott, J. 1988. Use of novel objects to enhance environments of captive chimpanzees. *Zoo Biology* **7:** 15–23.

Perdue, B. M., Clay A. W., Gaalema D. E., Maple T. L., Stoinski, T. S. 2012. Technology at the zoo: The influence of a touchscreen computer on orangutans and zoo visitors. *Zoo Biology* **31:** 27–39

Perlman, J. E., Bloomsmith, M. A., Whittaker, M. A., McMillan, J. L., Minier, D. E., McCowan, B. 2012. Implementing positive reinforcement animal training programs at primate laboratories. *Applied Animal Behaviour Science* **137**(3-4, Sp. Iss. SI): 114-126.

Petrželková, K., Schovancoá, K., Profousaová, I., Kišidayová, S., Váradyová, S., Pekár, S., Kamler, J. and Modry, D. 2012. The Effect of Low- and High-Fiber Diets on the Population of Entodiniomorphid Ciliates *Troglodytella abrassarti* in Captive Chimpanzees (*Pan Troglodytes*). *American Journal of Primatology* **74**(7):.669–675.

Piel, A.K., Stampelli, P., Greathead, E., Hernandez-Aguilar, A., Moore, J. and Stewart, F. 2017. The diet of open-habitat chimps (*Pan troglodytes schweinfurthii)* in Issa valley, western Tanzania. *Journal of Human Evolution* **112:** 57-69.

Plowman, A. 2016. 'Nutritional Requirements' paper presented at 3rd Primate Nutrition Workshop. Paignton Zoo, Devon. May 2016.

**Plumptre, A. J., Rose, R., Nangendo, G., Williamson, E. A., Didier, K., Hart, J., Mulindahabi, F., Hicks, C., Griffin, B., Ogawa, H., Nixon, S., Pintea, L., Vosper, A., McClennan, M., Amsini, F., McNeilage, A., Makana, J. R.,

Kanamori, M., Hernandez, A., Piel, A., Stewart, F., Moore, J., Zamma, K., Nakamura, M., Kamenya, S., Idani, G., Sakamaki, T., Yoshikawa, M., Greer, D., Tranquilli, S., Beyers, R., Furuichi, T., Hashimoto, C. and Bennett, E. 2010a. Eastern Chimpanzee *(Pan troglodytes schweinfurthii*): Status Survey and Conservation Action Plan 2010–2020. IUCN/SSC Primate Specialist Group, Gland, Switzerland.

Porteous, I. S., Mundy, N. I. and Grall, C. 1994. Use of intrauterine devices as a means of contraception in a colony of chimpanzees (*Pan troglodytes*). *Journal of medical primatology* **23**(6): 355-361.

Porton, I. 1992. Hand-rearing of captive chimpanzees. In: Fulk R, Garland C. (eds.), The care and management of chimpanzees (*Pan troglodytes*) in captive environments. A husbandry manual developed for the chimpanzee species survival plan. Asheboro (NC): North Carolina Zoological Society: 77-84.

Potts, K. B., Watts, D. P., and Wrangham, R. W. 2011. Comparative Feeding Ecology of Two Communities of Chimpanzees (*Pan troglodytes*) in Kibale National Park, Uganda. *International Journal of Primatology* **32:** 669-690.

Prado-Martinez, J., Sudmant, P.H., Kidd, J.M., Li H., Kelley J.L. *et al.* 2013. Great ape genetic diversity and population history. *Nature* **499:** 471–475.

Prescott, M. 2006. Primate sensory capabilities and communication signals: implications for care and use in the laboratory. National Centre for the Replacement, Refinement and Reduction of Animals in Research.

Pruetz, J. D. 2007. Evidence of cave use by savanna chimpanzees (*Pan troglodytes verus*) at Fongoli, Senegal: implications for thermoregulatory behavior. *Folia Primatologica* **48:** 316-319.

Pruetz, J. D. and Bertolani, P. 2007. Savanna chimpanzees, *Pan troglodytes verus*, hunt with tools. *Current Biology*, **17:** 412-417.

Pruetz, J. D., Boyer, K., Cleaveland, E., Lindshield, S., Marshack, J. and Wessling, **E. G.** (2017) Intragroup Lethal Aggression in West African Chimpanzees (*Pan troglodytes verus*): Inferred Killing of a Former Alpha Male at Fongoli, Senegal, *International Journal of Primatology*, 10.1007/s10764-016-9942-9, **38**(1): 31-57.

Pruetz, J. D. and McGrew, W. C. 2001. What does a chimpanzee need? Using behaviour to guide the care and management of captive populations. In: Brent, L. (ed.) 2001 The care and management of captive chimpanzees: 17-38. American Society of Primatologists. San Antonio, Texas.

Pusey, A. E. 1979. Intercommunity transfer of chimpanzees in Gombe National Park. In: Hamburg D, McCown E, editors. The great apes. California: Cummings: 465–479.

Quiatt, D., Reynolds, V. and Stokes, E. J. 2002. Snare injuries to chimpanzees (*Pan troglodytes*) at 10 study sites in East and West Africa. *African Journal of Ecology* **40:** 303–305.

Rainer, H., White, A. and Lanjouw, A. 2013. State of the apes – extractive industries and ape conservation. *Arcus Foundation*. Cambridge University Press.

Rainer, H., White, A. and Lanjouw, A. 2015. State of the apes – industrial agriculture and ape conservation. *Arcus Foundation*. Cambridge University Press.

Rainer, H. White, A. and Lanjouw, A. 2018. State of the apes – Infrastructure development and ape conservation. *Arcus Foundation*. Cambridge University Press.

Reamer, L. A., Neal Webb, S. J., Jones, R., Thiele, E., Haller, R. L. Schapiro, S. J. Lambeth, S. P., Hanley, P. W. 2020. Validation and utility of a body condition scoring system for chimpanzees (*Pan troglodytes). American Journal of Primatology* **82**(4): e23188. https://doi.org/10.1002/ajp.23188.

Reed, P. E., Mulangu, S., Cameron, K. N., Ondzie, A. U., Joly, D., Bermejo, M., Rouquet, P., Fabozzi, G., Bailey, M., Shen, A., Keele, B. F., Hahn, B., Karesh, W.B. and Sullivan, N. J. 2014. A new approach for monitoring Ebolavirus in wild great apes. *PLoS Neglected Tropical Diseases* **8**, e3143. https://doi.org/10.1371/journal.pntd.0003143

Reynolds, V. and Luscombe, G. 1971. On the Existence of Currently Described Subspecies in the Chimpanzee (*Pan troglodytes*). *Folia Primatologica* **14:** 129-138.

Rietschel, W. 2004. Tb or not Tb (nicht von Shakespeare). *Der Zoologische Garten.* **74:** 289-298

Rietschel, W. 1998. Zoonoses in primates in zoological gardens (including zoo-staff)” *EAZWV* **2:**71-84

Rival, A. and Levang, P. 2014. Palms of Controversies: Oil Palm and Development Challenges. CIFOR, Bogor, Indonesia.

Rosenblum, I. and Coulston, F. 1983. Impaired Renal Function in Diabetic Chimpanzees (*Pan troglodytes)*. Experimental and molecular pathology **38:** 224-229.

Ross, S. R., Calcutt, S., Schapiro, S. J. and Hau, J. 2011. Space use selectivity by chimpanzees and gorillas in an indoor-outdoor enclosure. *American Journal of Primatology* **73:** 197-208.

Ross, S. R., McNary, J. K. 2010. Chimpanzee (*Pan troglodytes*) Care Manual. Association of Zoos and Aquariums in Association with the AZA Animal Welfare Committee, Silver Spring, MD.

Ross, S. R., Melber, L. M., Gillespie, K. L. and Lukas, K. E. 2012. The Impact of a Modern, Naturalistic Exhibit Design on Visitor Behavior: A Cross-Facility Comparison. *Visitor Studies* **15:** 3-15.

Ross, S. R., Schapiro, S. J., Hau, H., and Lukas, K. E. 2009. Space use as an indicator of enclosure appropriateness: A novel measure of captive animal welfare. *Applied Animal Behaviour Science* **121:** 42–50

Ruysschaert, D. and Rainer, H. 2015. From process to impact of a voluntary standard: the roundtable on sustainable palm oil. In: *State of the apes: Industrial agriculture and ape conservation*: 135-163. Cambridge University Press, Cambridge.

Sabater-Pí, J. 1979. Feeding Behaviour and Diet of Chimpanzees (*Pan troglodytes troglodytes*) in the Okorobikó Mountains of Rio Muni (West Africa). *Zeitschrift für Tierpsychologie* **50**(3): 265–281

Sakura, O. 1994. Factors affecting party size and composition of chimpanzees (*Pan troglodytes verus*) Bossou, Guinea. *International Journal of Primatology,* **15**(2):167-183. https://doi.org/10.1007/BF02735272

Samson, D. R. and Hunt, K. D. 2012. A thermodynamic comparison of arboreal and terrestrial sleeping sites for dry-habitat chimpanzees (*Pan troglodytes schweinfurthii*) at the Toro-Semliki Wildlife Reserve, Uganda. *American Journal of Primatology* **74:** 811–818.

Sanz, C. M. and Morgan, D. B. 2007. Chimpanzee tool technology in the Goualougo Triangle, Republic of Congo. *Journal of Human Evolution* **52:** 420–433.

Sanz, C. M., and Morgan, D. B. 2011. Elemental variation in the termite fishing of wild chimpanzees (*Pan troglodytes*). *Biology Letters* **7:** 634-637.

Sanz, C. M., Schöning, C., and Morgan, D. B. 2010. Chimpanzees prey on army ants with specialized tool set. *American Journal of Primatology* **72:** 17-24.

Schapiro, S. J., Perlman, J. E., Thiele, E. and Lambeth, S. P. 2005. Training chimpanzees to voluntarily present for intramuscular injections using positive reinforcement training techniques. *American Journal of Primatology* **66:** 175

Schwarz, E. 1934. On the local races of the chimpanzee. *The Annals and magazine of natural history* **13:** 576-583.

Schwitzer, C., Polowinsky, S., and Solman, C. 2009. Fruits as foods – common misconceptions about frugivory. In: *Zoo animal nutrition IV* (ed. Clauss, M., Fidgett, A. L., Hatt, J. M., Huisman, T., Hummel, J., Janssen, G., Nijboer, J. and Plowman, A.): 131–168

Schel, A. M., Rawlings, B., Claidiére, N., Wilke, C., Wathan, J., Richardosn, J., Pearson, S., Herrelko, E. S., Whiten, A. and Sclocombe, K. 2013. Network analysis of social changes in a captive chimpanzee community following the successful integration of two adult groups. *American. Journal of Primatology* **75:** 254-266

Seed, A., Seddon, E., Greene, B. and Call, J. 2012. Chimpanzee 'folk physics': bringing failures into focus. *Philosophical Transactions of the Royal Society of London, B.* **367:** 2743–2752.

Seres, M., Aureli, F. and de Waal, F. B. M. 2001. Successful formation of a large chimpanzee group out of two pre-existing groups. *Zoo Biology* **20:** 501-515.

Shefferly, N., Fritz, J., Howell, S. 1993. Toys as environmental enrichment for captive juvenile chimpanzees (*Pan troglodytes*). *Laboratory Primate Newsletter* **32:** 7-9.

Shepherdson, D. J., Mellen, J. D. and Hutchins, M. 1998. Second Nature: Environmental Enrichment for Captive Animals. Washington: Smithsonian Institute.

Silk, J., Brosnan, S., Henrich, J., Lambeth, S. and Shapiro, S. 2013. Chimpanzees share food for many reasons: the role of kinship, reciprocity, social bonds and harassment on food transfers. *Animal Behaviour* **85**, 941-947.

Shora, J., Myhill., M. and Brereton, J. 2018. Should zoo foods be coati chopped? *Journal of zoo and aquarium research* **6**(1): 22-25.

Smith, A., Lindburg, D. and Vehrencamp, S. 1989. Effect of food preparation on feeding behaviour of lion-tailed macaques. *Zoo biology* **8:** 57-65.

Sop, T., Mundry, R., Colleen, S. and Kühl, H. In prep. Report on estimated trends in abundance of western chimpanzees (*Pan troglodytes verus*).

Spiezio, C., Vandelle, C., Regaiolli, B. and Sandri, C. 2017. How do we measure the effectiveness of environmental enrichment for zoo chimpanzees' welfare? *Proceedings of the International Symposium: Measuring animal welfare and applying scientific advances - Why is it still so difficult?:* 27-29. Southern England.

Stanford, C. B. 1999**.** The hunting apes: meat eating and the origins of human behavior. Princeton University Press.

Stanford, C. B., Wallis, J., Matama, H., and Goodall, J. 1994. Patterns of predation by chimpanzees on red colobus monkeys in Gombe National Park, 1982-1991. *American Journal of Physical Anthropology* **94:** 213-228.

Stanford, C. B., Wallis, J., Mpongo, E., and Goodall, J. 1994. Hunting decisions in wild chimpanzees. *Behaviour* **131:** 1-18.

Stevens, J. and Van Elsacker, L. 2005. The successful integration of an adult male chimpanzee in a multi-male, multi-female group. *Proceedings of the 7th Annual Symposium on Zoo Research*.

Stiles, D., Redmond, I., Cress, D., Nelleman, C., Formo, R.K. (Eds.) 2013. Stolen Apes – the illicit trade in chimpanzees, gorillas, bonobos and orangutans. UNEP/UNESCO.

Stoinski, T.S., Ogden, J.J., Gold, K.C., Maple, T.L. 2001. Captive apes and zoo education. In: B.B. Beck, T.S. Stoinski, M. Hutchins, T.L. Maple, B. Norton, A. Rowan, E.F. Stevens, A. Arluke (Eds.), Great apes & humans: The ethics of coexistence. Washington, DC: Smithsonian Institution Press: 113–132.

Stokes, R., Tully, G. and Rosati, A. G. 2018. Pan African Sanctuary Alliance: securing a future for the African great apes. *International. Zoo Yearbook* **52:** 173-181

Strindberg, S., Maisels, F. *et al.* Guns, germs and trees: key factors influencing the status of gorillas and chimpanzees in Western Equatorial Africa. DOI: 10.1126/sciadv.aar2964

Strong, V., Baiker, K., Brennan, M., Redrobe, S., Rietkerk, F., Cobb, M. and White, K. 2017. A retrospective review of western lowland gorilla (*Gorilla gorilla gorilla*) mortality in European zoologic collections between 2004 and 2014. *Journal of Zoo and Wildlife Medicine* **48**(2): 277-286

Strong, V. J., Martin, M., Redrobe, S., White, K. and Baiker, K. 2018. A retrospective review of great ape cardiovascular disease epidemiology and pathology. *International. Zoo Yearbook* **52:** 113-125

Strong, V. J., Sheppard, M. N., Redrobe, S. and Baiker, K. 2018. Guidelines for consistent cardiovascular post-mortem examination, sampling and reporting of lesions in European-housed great apes. *International. Zoo Yearbook* **52:** 126-136

Struck, K., Videan, E., Fritz, J. and Murphy, J. 2007. Attempting to reduce regurgitation and reingestion in a captive chimpanzee through increased feeding opportunities: a case study. *Laboratory Animal* **36**(1): 35-38.

Suarez, S. and Forter, L. 1995. Chimp platforms in outdoor enclosures. *The Shape of Enrichment* **4***:* 5–6.

Sugiyama, Y. (2004) Demographic parameters and life history of chimpanzees at Bossou, Guinea. *American Journal of Physical Anthropology* **124:** 154–165

Swaisgood, R. R., Shepherdson, D. J. 2005 Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biology* ***24:*** 499-518

Takemoto, H. 2004. Seasonal change in terrestriality of chimpanzees in relation to microclimate in the tropical forest. *American Journal of Physical Anthropology* **124:** 81-92

Teleki, G. 1973. The predatory behavior of the wild chimpanzee*.* Brunswik: Bucknell University Press.

Tennie, C., Gilby, I. C., and Mundry, R. 2009. The meat-scrap hypothesis: small quantities of meat may promote cooperative hunting in wild chimpanzees (*Pan troglodytes*). *Behavioral Ecology and Sociobiology* **63:** 421-431

Tennie, C., Malley, R. and Gilby. I. 2014. Why do chimpanzees hunt? Considering the benefits and costs of acquiring and consuming vertebrate versus invertebrate prey. *Journal of human evolution* **71:** 38-45.

Terio, K., McAloose, D. and St. Leger, J. 2018: Pathology of Wildlife and Zoo Animals, 1st ed, Academic Press

Thompson, M. and Wrangham, R. 2008. Diet and reproductive function in wild female chimpanzees (*Pan troglodytes schweinfurthii*) at Kibale National Park, Uganda. *American Journal of Physical Anthropolog*y **135:** 171-181

Townsend, S. W., Slocombe, K. E., Emery Thompson, M., Zuberbühler, K. (2007) Female-led infanticide in wild chimpanzees. *Current Biology* **17(10):** R355–R356. https://doi.org/10.1016/j.cub.2007.03.020

Traylor-Holzer, K., & Fritz, P. 1985. Utilization of space by adult and juvenile groups of captive chimpanzees (*Pan troglodytes*). *Zoo Biology* **4**(2): 115-127 http://dx.doi.org/10.1002/zoo.1430040205

Tutin, C. E. G. 1980. Reproductive behavior of wild chimpanzees in the Gombe National Park, Tanzania. *Journal of Reproductive Fertility Supplement* **28:** 43-57

Tutin, C.E.G. and Fernandez, M. 1992. Insect-eating by sympatric Lowland gorillas (*Gorilla g. gorilla*) and chimpanzees (*Pan troglodytes troglodytes*) in the Lopé Reserve, Gabon. *American Journal of Primatology* **28**(1): 29–40

Tutin, C. E. G., & Fernandez, M. 1993. Composition of the Diet of Chimpanzees and Comparisons with that of Sympatric Lowland Gorillas in the Lopé Reserve, Gabon. *American Journal of Primatology*, **30:** 195-211

Tutin, C. E. G., Ham, R., White, L. and Harrison, M. 1997. The primate community of the Lope Reserve, Gabon: Diets, responses to fruit scarcity, and effects on biomass. *American Journal of Primatology*, **42**(1): 1–24

Tweh, C. G., Lormie, M. M., Kouakou, C. Y., Hillers, A., Kuhl, H. S. and Junker, J. 2015. Conservation status of chimpanzees *Pan troglodytes verus* and other large mammals in Liberia: a nationwide survey. *Oryx* **49:** 710–718

University of Birmingham. 2016. Enclosure Design Tool (EDT).
https://www.birmingham.ac.uk/schools/biosciences/research/showcase/enclosure-design-tool/index.aspx

Vaidyanathan, G. 2011. The cultured chimpanzees. *Nature* **476:** 266-269

Van Hooff, J. 1967. The care and management of captive chimpanzees with special emphasis on the ecological aspects (Rep. No. ARL–TR–67–15). 6571st Holloman Air Force Base, NM: Aeromedical Research Laboratory.

Van Lawick-Goodall, J. 1968**.** The Behaviour of Free-living Chimpanzees in the Gombe Stream Reserve. London. Baillière, Tindall & Cassell

Van Leeuwen, K.L., Ross A.H. and Korstjens, A.H. 2020. Classifying Chimpanzee (*Pan troglodytes*) Landscapes Across Large-Scale Environmental Gradients in Africa. *International Journal of Primatology* ***41****:800–821*

Varki, N., Anderson, D., Herndon, J., Pham, T., Gregg, C., Cheriyan, M., Murphy, J., Strobert, E., Else, J. and Varki, A. 2008. Heart disease is common in human and chimpanzees but is caused by different pathological processes. *Evolutionary Applications:* 101-112

Veasey, JS. 2017. In pursuit of peak animal welfare; the need to prioritize the meaningful over the measurable. *Zoo Biology* **36**(6)**:** 413-425.

Vermeer, J. 2009. Boys will be boys. *EAZA News* **67:** 23

Videan, E., Fritz, J., and Murphy, J. 2007. Development of guidelines for assessing obesity in captive chimpanzees (*Pan troglodytes*). *Zoo Biology* **26:** 93-104.

Videan, E., Heward, C. B., Fritz, J., Murphy, J. and Cortez, C. 2007. Relationship between sunlight exposure, housing condition, and serum vitamin D and related physiologic biomarker levels in captive chimpanzees (*Pan troglodytes*). *Comparative Medicine* **57**(4):402-6

Walsh, P. D., Abernethy, K. A., Bermejo, M., Beyersk, R., De Wachter, P., Akou, M. E., Huijbregts, B., Mambounga, D. I., Toham, A. K., Kilbournk, A. M., Lahmq, S. A., Latourk, S., Maiselsk, S. F., Mbinak, C., Mihindouk, Y., Obiang, S. N., Effa, E. N. and Starkeyk, M. 2003. Catastrophic ape decline in western equatorial Africa. *Nature* **422:** 611–614

Walsh, P. D., Biek, R. and Real, L.A. 2005. Wave-like spread of Ebola Zaire. *PLoS Biology* **3:** 1946–1953

Watts, D. P., and Mitani, J. C. 2002. Hunting Behavior of Chimpanzees at Ngogo, Kibale National Park, Uganda. *International Journal of Primatology* **23:** 1-28

Watts, D., Potts, K., Lwanga, J. and Mitani, J. 2012a. Diet of chimpanzees (*Pan troglodytes schweinfurthii*) at Ngogo, Kibale National Park, Uganda, 1. Diet composition and diversity. *American Journal of Primatology* **74**(2): 114–129

Watts, D., Potts, K., Lwanga, J. and Mitani, J. 2012b. Diet of chimpanzees (*Pan troglodytes schweinfurthii*) at Ngogo, Kibale National Park, Uganda, 2. Temporal variation and fallback foods. *American Journal of Primatology* **74**(2): 130–144.

Wehnelt, S., Bird, S. and Lenihan, A. 2006. Chimpanzee Forest exhibit at Chester Zoo. *International Zoo Yearbook* **40:** 313-322

West, G., Heard, D. and Caulkett, N (Eds.). 2014. Zoo animal and wildlife immobilization and anesthesia, 2. Ed. Wiley-Blackwell.

Whiten, A., Goodall, J., McGrew, W. C., Nishida, T., Reynolds, V., Sugiyama, Y., Tutin, C. E. G., Wrangham, R. W. and Boesch, C. 1999. Cultures in chimpanzees. *Nature* **399:** 682-685

Wich, S. A., Garcia-Ulloa, J., Kühl, H. S., Humle, T., Lee, J. S. and Koh, L. P. 2014. Will oil palm's homecoming spell doom for Africa's great apes? *Current Biology* **24:** 1659–1663

Wich, S. A. & Marshall, A. J. (Eds.) 2016. An introduction to primate conservation. Oxford University Press.

Wielebnowski, N. 2003. Stress and distress: evaluating their impact for the well-being of zoo animals. *Journal of the American Veterinary Medical Association*. **223** (7): 973-7.

Williams, J. M., Lonsdorf, E. V., Wilson, M. L., Schumacher-Stankey, J., Goodall, J. and Pusey, A. E. 2008. Causes of death in the Kasekela chimpanzees of Gombe National Park, Tanzania. American Journal of Primatology **70**(8): 766-777

Williamson, E. A., Maisels, F. G., and Groves, C. P. 2013. Hominidae (Great Apes). In: Handbook of the Mammals of the world Volume 3: Primates (Eds. R. A. Mittermeier, A. B. Rylands & D. E. Wilson). Lynx Edicions. Barcelona, Spain: 792-854

Wilson, M. L., Boesch, C., Fruth, B. *et al.* (2014). Lethal aggression in *Pan* is better explained by adaptive strategies than human impacts*. Nature* **513:** 414-417

Wingfield*,* J. C., Sapolsky R. M. *2003.* Reproduction and Resistance to Stress When and How. *Journal of Neuroendocrinology* **15**: 711-724

Worstell, C. 2003. Reconciling User Needs in Animal Exhibit Design: Gorilla exhibits as a case study (ZooLex Zoo Design Organization). https://www.zoolex.org/media/uploads/2019/01/04/2008_worstell_carlyn_gorillas.pdf

Wrangham, R.W. 1977. Feeding behaviour of chimpanzees in Gombe National Park, Tanzania. In: Clutton-Brock, T. Primate Ecology: Studies of Feeding and Ranging Behavior in Lemurs, Monkey and Apes**:** 503–538.

Wrangham, R. (2000) Why are male chimpanzees more gregarious than mothers? A scramble competition hypothesis. In: Kappeler, P. (ed) Primate males. Causes and consequences of variation in group composition. Cambridge University Press, Cambridge: 248–258

Wrangham, R. W., Conklin, N. L., Chapman, C. A., and Hunt, K. D. 1991. The significance of fibrous food for Kibale Forest chimpanzees. *Philosophical Transactions of the Royal Society B: Biological Sciences* **334:** 171-178

Wrangham, R. W., Conklin-Brittain, N. L., and Hunt, K. D. 1998. Dietary Response of Chimpanzees and Cercopithecines to Seasonal Variation in Fruit Abundance. I. Antifeedants. *International Journal of Primatology* **19:** 949-970

Wrangham, R., McGrew, W., de Waal, F. and Heltne, P. (Eds.) 1994. Chimpanzee cultures. Harvard University Press. Cambridge Massachusetts.

Wrangham, R. and Peterson. D. 1996. Demonic males - apes and the origins of human violence. Bloomsbury, London.

Xue, Y., Prado-Martinez, J., Sudmant, P.H., Narasimhan, V., Ayub, Q., Szpak, M., Frandsen, P., Chen, Y., Yngvadottir, B., Cooper, D.N., de Manuel, M., Hernandez-Rodrigues, J., Lobon, I., Siegismund, H.R., Pagani, L., Quail, M.A., Hvilsom, C., Mudakikwa, A., Eichler, E.E., Cranfield, M.R., Marques-Bonet, T., Tyler-Smith, C., and Scally, A. 2015. Mountain gorilla genomes reveal the impact of long-term population decline and inbreeding. *Science* **348** (6231): 242-245.

Yamagiwa, J. and Basabose, K. 2009. Fallback foods and dietary partitioning among pan and gorilla. *American Journal of Physical Anthropology* **140:** 739-750.

Yamakoshi, G. 1998. Dietary responses to fruit scarcity of wild chimpanzees at Bossou, Guinea: possible implications for ecological importance of tool use. *American Journal of Physical Anthropology* **106:** 283-295.

Yamanashi, Y., Hayashi, M. 2011. Assessing the effects of cognitive experiments on the welfare of captive chimpanzees (*Pan troglodytes*) by direct comparison of activity budget between wild and captive chimpanzees. *American Journal of Primatology* **73:** 1231–1238

Yerkes, R. M., Elder, J. H. 1936. The sexual and reproductive cycle of the chimpanzee. *Proceedings of the National Academy of Science (USA)* **22:** 276-283

Young, R. J. 2013. Environmental Enrichment for Captive Animals. London: Blackwell Publishing.

Young, W. C., Yerkes, R. M. 1943. Factors influencing the reproductive cycle of the chimpanzee; the period of adolescent sterility and related problems. *Endocrinology* **33:** 121-154.

Zimmerman, B.L. and Kormos, C.F. 2012. Prospects for sustainable logging in tropical forests. *BioScience* **62:** 479–487

SECTION 4. APPENDICES

4.1 Appendix I: Comprehensive guide to conducting intake studies (*cf* Bishop (2013))

Appendix I

Appendix I. Conducting an Intake Study

Ideally the study involves 5 consecutive days of measuring individual diet components both offered and remaining. To approximate a normal diet schedule, collection during the 5 day study period should ideally be performed by the primary keepers for the animals.

- All feed items must be weighed individually before feeding.
- Items may be mixed after they have been weighed.
- A desiccation dish must be set up separately from the main feed, to measure the amount of water lost to the air. This dish should be placed in an area as similar as possible to the exhibit being evaluated but with no animal access.
- All items must be separated after animals have been fed. Each item must again be weighed separately and recorded. If this is not possible due to items being mixed into a mixed 'porridge' the total amount remaining should be weighed and the amounts of each food type remaining estimated from the relative amounts used to make the mixture.
- Remaining food amounts need to be adjusted using desiccation factors measured from the desiccation dish.

Recording Feed Intake

- Prepare a list of feeds that are included in each animal's diet and note the number of animals in the exhibit.
- Locate and become familiar with the scale that will be used.
- Weigh each item of the diet separately.
- Record individual feed weights for each dish, or the total if the food is being scattered. Be sure to note any supplements. If an in-house mix of ingredients is prepared, the components and recipe will be necessary for full evaluation. Also note ingredient types, brands, and any other specific information available.
- Feed animal.
- After "normal" amount of feeding time (i.e., animal is fed in AM and PM), retrieve feed dishes and/or collect all food items remaining in the exhibit.
- Separate all feed items from each other.
- Weigh each item individually (including discarded items) and record on intake sheet.
- Continue this procedure for 5 consecutive days.

Desiccation/Absorption Dish

The purpose is to estimate the amount of moisture lost to (or gained from) the environment of the exhibit while the food sits out. Select a site for this dish that is as similar to the exhibit being measured as possible. Try to select an area that will minimize the amount of loss to rodents and insects.

- Weigh all items into the dish and then leave it out for the same amount of time as the main diet.
- When feed dishes are collected, the desiccation dish can also be evaluated.
- Follow the same procedure as above for measurements; record data on a daily desiccation record sheet.

Calculations

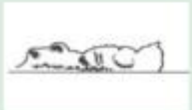
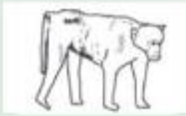
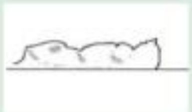
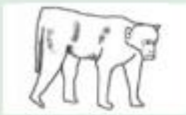
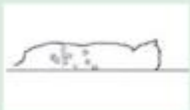
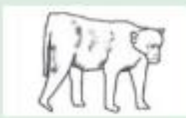
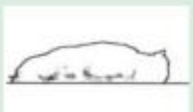
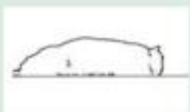
Sample calculations are for one item only. It will be necessary to repeat for each ingredient, on each day of the trial. Numbers in **BOLD** are measured, all others are calculated using the instructions below:

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
				Desiccation Dish		*Correction*	*Corrected*	
All wts in grams	*Offered*	*Remains*	*Start*	*End*	*Difference*	*Factor (as %)*	*Remains*	*Eaten*
APPLE	**821**	**54**	**200**	**190**	10	0.05	57	764

- Calculate desiccation *correction factor* (F) by first calculating the difference in weight [C-D = E] in the dessication dish, then expressing this as a percentage of the initial weight [E/C = F]. In the example above, the correction factor would be reported as 5%, but for calculations in the spreadsheet is expressed as a fraction (0.05).
- Apply correction factor to feed remains then add to feed remains to calculate *corrected remains* [(BxF)+B = G].
- Use corrected remains to calculate how much was *eaten* [A-G = H]. Since original measurements were in whole numbers, it is appropriate to round values accordingly.
- Use columns A and H to describe diets in terms of food quantities offered and eaten. Estimate nutrients offered and consumed using food tables or diet management software.

4.2 Appendix II: Body Condition Scoring guide for primates

TABLE 1 | Body condition scoring system for nonhuman primates. Stylized drawings of ambulating animals and animals in right lateral recumbency attempt to visually depict bony prominences, muscle, and fat that are palpated when scoring animals. Note that animals may not actually appear as drawn because of the presence of the haircoat.

		Ambulating	Right lateral viewed from back
1	**EMACIATED** – Very prominent hip bones (easily palpable and likely visible), prominent facial bones, spinous processes, and ribs. Minimal to no muscle mass is palpable over ilium or ischium. Anus may be recessed between ischial callosities. Body is very angular, no subcutaneous fat layer to smooth out prominences.		
1.5	**VERY THIN** – Hips, spinous processes, and ribs are prominent. Facial bones may be prominent. There is very little muscle present over the hips and back. Anus may be recessed between ischial callosities. Body is angular, no subcutaneous fat to smooth out prominences.		
2	**THIN** – Very minimal fat reserves, prominent hip bones and spinous processes. Hips, spinous processes, and ribs are easily palpable with only a small amount of muscle mass over hips and lumbar region		
2.5	**LEAN** – Overlying muscle gives hips and spine a more firm feel. Hip bones and spinous processes are readily palpable, but not prominent. Body is less angular because there is a thin layer of subcutaneous fat.		
3	**OPTIMUM** – Hip bones, ribs, and spinous processes are palpable with gentle pressure but generally not visible. Well-developed muscle mass and subcutaneous fat layer gives spine and hips smooth but firm feel. No abdominal, axillary, or inguinal fat pads.		
3.5	**SLIGHTLY OVERWEIGHT** – Hip bones and spinous processes palpable with firm pressure but are not visible. Bony prominences smooth. Rib contours are smooth and only palpable with firm pressure. Small abdominal fat pad may be present.		
4	**HEAVY** – Bony contours are smooth and less well defined. Hip bones, spinous processes, and ribs may be difficult to palpate because of more abundant subcutaneous fat layer. May have fat deposits starting to accumulate in axillary, inguinal, or abdominal areas.		
4.5	**OBESE** – This animal will often have prominent fat pads in the inguinal, axillary, or abdominal region. Abdomen will be pendulous when animal is sitting or ambulating. Hip bones and spinous processes difficult to palpate. Bony contours smooth and poorly defined.		
5	**GROSSLY OBESE** – Obvious, large fat deposits in the abdominal, inguinal and axillary regions. Abdominal palpation is very difficult due to large amount of mesenteric fat. Pronounced fat deposits may alter posture/ambulation. Hip bones, rib contours, and spinous processes only palpable with deep palpation.		

4.3 Appendix III: - The function and significance of "GAP" setting during introductions -

Michael Seres

(Referenced from page 52 in section 2.1.1.10 Animal doors and from page 119 in section 2.7.2.1 Dyadic introductions)

Pdf of the presentation: https://www.eaza.net/assets/Uploads/CCC/Other/Chimpanzee-BPG-Appendix-III-Michael-Seres-The-function-and-significance-of-GAP-setting-during-introductions.pdf

4.4 Appendix IV: Ape TAG Bio floor Survey for great apes in indoor enclosures. Results presented at the ape TAG meeting of the EAZA conference 2007 in Warsaw

Marianne Holtkötter

Definition of bio floor: deep (at least 10 cm) litter of natural substrate. (A concrete floor with some bedding/nesting material is not a bio floor!)

The survey consisted of the following questions:

1. Do you use a bio floor (natural substrate in indoor exhibits instead of a concrete floor, e.g., straw, bark, woodchips, soil, flax-fibre, hemp-fibre, peat…) for apes at your zooor have you used it in the past?
2. If you do NOT use it (anymore): What are your main reasons against it?
3. If you use(d) it: For which ape species?
4. Which material does your bio floor consist of, e.g., which species of tree does yourmaterial come from, and which parts (bark, wood, fibre) do you use?
5. Why did you choose just this material? (Maybe you know of bad experiences withanother material?)
6. Which size (length) do the bark or wood chips have when you first bring them in?(e.g., below 2 cm, between 2-4 cm, mixture between x and y cm)
7. How deep is your bio floor and what is the enclosure surface (in m²) you have coveredwith it?
8. Which sort of drainage do you use for it?
9. When cleaning (walls, windows, climbing structures), what detergents do you use, anddo these affect the bio floor?
10. How often do you completely exchange the bio floor?
11. What is your regular routine to keep the bio floor “clean”, e.g. Do you clean the surface daily and add new chips? Do you experience that the top layer becomes compacted (does not absorb fluids anymore) so that you have to dig into and loosenthe material daily? And how much time does this take one keeper daily?
12. Does the maintenance of the bio floor take more time than cleaning hard (e.g., concrete)floors? Does it cause more back pain to your keepers (can be a serious problem when digging up the top layer)?
13. Have you ever analysed bio floor samples for bacterial or fungal content? And did youhave any relevant results that made you change your bio floor routine?
14. How do you control humidity of the bio floor to avoid dust (too dry) and Aspergillus(mouldy patches, too moist)?
15. Did you experience problems with aspergillosis, shigellosis or other pathogens andhow did/do you solve this?
16. Did you experience pest control problems (rodents, cockroaches) and how did/do yousolve these?

17. Did you have any other problems/disadvantages using bio floor and how did you solvethem?

18. All in all: If you use bio floor: which advantages outweigh the possible problems inyour opinion?

57 zoos have returned the survey (see list at the end).

Of these 57 zoos 25 have at least one bio floor.

The bio floors are for the following species of great ape:

15x gorillas
9x orangutans2x
bonobos
11x chimpanzees
which makes up 37 bio floors.

Only 2 zoos say they are not happy with their bio floors:

Antwerp (no drainage, dust)

Amsterdam (substrate is not deep enough)

This means 35 bio floors are working more or less fine!

31 of the 57 zoos returning the questionnaire do NOT have a bio floor. They keep the following species of great ape on concrete floors (with different sorts and amounts of beddingmaterials):

18x gorillas

17x orangutans3x
bonobos

20x chimpanzees

which makes up 58 concrete floors.

Bio floors are recommended in the EEP husbandry guidelines for gorillas and bonobos. According to the results of this questionnaire about half of the gorilla holders keep theirgorillas on bio floors (15 bio floors versus 18 concrete floors).

One third of the bonobo holders in the EEP keep their bonobos on bio floors (3 out of 9).One third of the orangutan holders use bio floors (versus 17 concrete floors).

And also one third of the chimpanzee holders use bio floors (versus 20 concrete floors).

The following reasons AGAINST the use of bio floors were given by zoos using concretefloors:

- 20 x: enclosure not suited for the use of bio floor (e.g., no drainage, doors and slidingdoors on

concrete floor level do not allow deep litter)
- 6 x: hygienic concerns
- 1 x no information how to do a bio floor properly
- 3 x: bad experience with bio floor (dust, disease)

However: in 16 of these cases the zoo considers using bio floors in the future – after seeing theresults of this survey.

Material used for bio floors:

- 9x pine bark
- 2x conifer bark
- 1x spruce bark
- 4x pine woodchips
- 3x mixture of bark and woodchips
- 2x wood pieces (oak, beech)
- 2x natural soil/sand (for orangutans)
- 6x top layer of straw, woodwool, hay, haylage

The reasons given for choosing the material were: It is easily available, cheap, or wasrecommended by another zoo.

The pieces of which the material consists measure:

- 10x up to 4 cm
- 8x up to 10 cm
- 3x up to 30 cm

The depth of the bio floor varies between zoos:

1x 10 cm
5x 10-20 cm
3x 20-30 cm
5x 30-40 cm
8x 40-50 cm
4x 50-60 cm4x > 60 cm

So, 9 zoos have their bio floors up to 30 cm deep, whereas 21 zoos have it deeper than that.

The following types of drainage (also in combination) are used:

- 10x sloping concrete floor, central drain (channel) (The sink is sometimes outside ofthe enclosure!)
- 16x wire mesh, membrane, drainage mats
- 3x stones
- 1x natural soil
- 4x none

The following kinds of detergent are used for cleaning windows, walls, climbing structures:

- 11x green/biodegradable soap
- 5x none (only water, power hose)
- 2x disinfectant/bactericide
- 3x vinegar (for glass windows)
- 4x washing up liquid

Cleaning the bio floor:

Removing faeces, rests of food, wet substrate (urine) once or twice daily takes 30-60 (at maximum 120) minutes for one keeper, which is – compared to cleaning a concrete floor –

- less time (10x)
- more time (2x)
- same time (1x).

Filling up or exchanging the bio floor takes additional time. How much depends on thetechnical conditions and constructions.

Watering the bio floor is done by spraying, hosing, complete watering, misters, sprinklers…. This varies a lot between zoos. It depends on how moist they want the floor to be, somewherein between too wet (risk of fungi) and too dry (risk of dust). It is a challenge for the keepers tofind and keep the right humidity level (most zoos want a humidity level of 60-70%).

The frequency of loosening the top layer (by digging, raking) varies between once per day and once per month.

The frequency of filling up substrate also varies:

- 1x once per day
- 2x once per week
- 1x once per month
- 8x a few times per year
- 1x once per year.

The following zoos have exchanged their bio floors completely

- after 6 months: Antwerp, Dublin, Prague (for gorillas)
- after one year: Prague (for orangutans), Basel (turned out to be unnecessary)
- after 5 years: Romagne (turned out to be unnecessary).

The following zoos have never exchanged their bio floors since:

- 1 year: Beekse Bergen
- 2 years: Kerkrade
- 3 years: Arnhem
- 4 years: Hamburg
- 5 years: La Boissière
- 7 years: Apenheul, Heidelberg (both for gorillas)
- 8 years: Givskud
- 9 years: Frankfurt (gorillas)
- 12 years: Frankfurt (bonobos)
- 13 years: Zürich (gorillas).

Analysis of bio floor substrate:

17 out of 25 zoos using bio floors have never analysed their substrate. Some analysis was doneat the zoos of Basel, Antwerp, Amsterdam, Dublin, Heidelberg, Frankfurt and Amersfoort.

The following parasites/pathogens were found

- mites (Ramat Gan)
- Strongyloides (Basel)
- Ascarids (Basel, Heidelberg)
- Balantidium (Basel, Dublin, Kerkrade tolerates Balantidium to a certain level)
- Coccidium (Basel)
- Yersinia (Dublin)
- Shigella (Romagne)
- Conidiobolus coronatus (Antwerp)
- Trongolytella (Dublin)
- Enterovirus (Dublin)

Some zoos analyse faecal samples for control.

Pests and pest control:

The following pests were found

- 18x rodents
- 7x cockroaches
- 2x crickets
- 1x ants
- 1x frogs (Givskud Zoo, more pets than pest)Means of pest control used

- destroy holes/nests by digging
- traps
- bait boxes/ poison (placed outside of enclosure!)
- flooding the floor completely
- predators: mangabeys, cats, mongoose, genet, meerkats
- professional pest control service

Summing up

The following **disadvantages** of using a bio floor were listed:

- sliding doors are blocked by substrate
- can become dusty if not kept humid, thus causing scratching and hair loss
- animals throw chips
- pests
- parasites, pathogens

The following **advantages** of using a bio floor were listed as outweighing the problems:

- saves cleaning time
- good for hands, feet, hair, and skin condition
- good for resting, walking, nest building
- enrichment
- more natural
- nice view for visitors
- helps to keep humidity high
- acids help to kill bacteria
- smells good
- reduces noise level
- warm
- inexpensive
- lowers risks when animals play/ fight
- clearly preferred by the animals (compared to concrete floor).

Conclusion

IF you plan a bio floor, take care of the following things:

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

Many thanks to all the colleagues who helped to "design" the survey, returned the survey, sent photos and/or samples of their bio floor substrate, and replied to additional questions!!!

The results above are based on the surveys returned from the following zoos:

Givskud
Aalborg
Boras

Gävle/Furuvik
Basel
Zürich
Monde Sauvage
Antwerp/PlanckendaelBeekse Bergen
Gaia Park KerkradeAmsterdam
Arnhem
Apenheul
Colchester
Dudley
Banham
Paignton
Twycross
London
Bristol
Belfast
Dublin
La Palmyre
St Martin la Plaine
La Boissière du Doré
Beauval
Romagne
La Barben
Amnéville
Barcelona
Las Aguilas/Tenerife
Palmitos Park/Gran Canaria
Nürnberg
Hamburg
Heidelberg
Bremerhaven
Augsburg
Nordhorn
Münster
Frankfurt
Gelsenkirchen
Stuttgart
Zagreb
Zlin-Lesna
Prag
Ostrava
Gdansk
Opole
Warsaw
Budapest
Moscow
Kaliningrad
Rostov
Ramat Gan
Johannesburg
Sidney
Melbourne

4.5 Appendix V: EAZA Great Ape Taxon Advisory Group (GATAG) Hand rearing Statement

GUIDELINE ON THE HAND-REARING AND EARLY INTEGRATION OF INFANT APES

It is strongly recommended to leave young apes with their mothers whenever possible.

The following circumstances are examples where the welfare of the individuals concerned demands to take some sort of action:

- when a mother gives birth to twins, but cannot cope.
- when social conditions threaten infant survival.
- when a mother is too ill or inexperienced to care for her young.
- when an infant is abandoned by its mother.
- when the baby is too ill or weak to suckle.

Under such circumstances, one or more of the following actions should be considered to bring about natural rearing:

- encouraging the mother vocally.
- separating the mother and baby to give them some peace.
- separating aggressive group members if it helps to calm the mother down.
- a trusted keeper showing the mother what she is supposed to do.
- anaesthetizing the mother and putting the baby in the right position to suckle.
- supplementary feeding with the infant still being with its mother or another female of the same species willing to accept it.
- surrogacy / foster rearing by another ape (maybe at another zoo).

In the event of a potential case of 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 suckle/rear her offspring. At least 48 hours can usually be allowed to elapse before non-suckling becomes a concern as newborn apes can usually survive at least as long as this without having suckled. The ability to hold the head up, strength of clinging reflex and frequency of crying may give indications of the condition of infant and the degree of urgency to take action in one of the ways mentioned above. Therefore, after the female gives birth, the situation should be watched closely by preferably only one person and at least for the first 3-4 days, especially in the case of a primiparous female or a female who has shown a lack of maternal behaviour before. Care must be taken that the mother/group does not feel disturbed by being watched or by the presence of video camera equipment.

In such situations of potential maternal neglect, it is strongly recommended that institutions contact the EEP coordinator of the ape species concerned or other

experienced colleagues from the species committee to help them find the best solution and decide if hand-rearing is unavoidable and/or if early (re-)introduction or the transfer to a nursery is advisable. In case that an institution does not follow the advice of the EEP, *it must be prepared to keep the animal for the rest of its life.*

An infant's long-term future and the likelihood of successful reintegration should also be taken into account before finally deciding to hand-rear it. Euthanasia should only be considered (if allowed under national laws) after consultation with the owner, the EEP coordinator, the TAG or species vet advisor, the zoo vet, and (depending on the zoo's policy) the vet of the official authority. It is an option where long-term welfare is compromised. This includes besides medical aspects (e.g., pain, treatment stress) as well social (e.g., isolation), behavioural (e.g., inability to climb or groom) and breeding (e.g., "bad" genetics, lack of space) aspects. The EAZA euthanasia guidelines should be consulted.

It is better to leave the infant with its mother for as long as the mother is behaving in an acceptable way, to give her more maternal experience.

<u>**Guidelines if hand-rearing is decided**</u>

If the baby has to be taken away from the mother to save its life, initial care should preferably be given by an experienced keeper and following methods, which have proved to be successful.

The hand-rearing of apes alone or with other species, when there is a possibility to rear them with conspecifics, is to be avoided whenever possible

In the case that there is no realistic prospect for an early socialization / reintegration into a group or when attempts to do so have failed, it is recommended to rear the baby together

with conspecifics in an ape nursery. In such a nursery, contact to/socialization with adult conspecifics is desirable to prepare the infant for the integration into a family group.

If an infant is to be transferred to a nursery this should take place before the age of 4 month so that it gets contact with conspecifics as soon as possible.

Early introduction to a group other than the natal group should only be considered if there is no anticipated risk of infanticide.

Early (re-) introduction is only recommended if conditions seem promising.

Conditions which are more likely to result in a successful early introduction include:

- a well-balanced, stable group
- an adult and socially experienced group member that is:
  - willing to take, keep and protect the infant.
  - allowed to do so by the other group members.
  - lactating, or trained to allow bottle-feeding of the infant.
- suitable facilities e.g., an enclosure which:

– allow visual, auditory and olfactory contact by the infant to the group.

– offers protected physical contact through wire mesh.

– has selective sliding doors through which only the infant can pass in order to be fed or to escape from aggression.

- other (preferably mother-reared) infants in the group (whilst being mindful that juveniles may be aggressive towards a new 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.

In the case of early introduction / reintroduction of the hand-reared baby to the natal or another group, this must be started as early as possible. Building up a relationship starts with carrying the baby to the group (as soon as its health is stable enough) and making contact through the wire-mesh for the initial months of life.

Such integrations should be finished (i.e., the infant being in the group all day) at 18 months of age. However, full integration may be possible much sooner.

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

- re-examining the present husbandry management of the ape taxon concerned.
- possible transfers within the EEP in discussion with the relevant EEP species committee.
- preventing the female concerned from being mated / contracepting the female concerned in order to avoid pregnancy i.e., until she has observed a model for maternal behaviour.

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

Produced for EAZA Great Ape TAG by Neil Bemment, Bengt Holst, Marianne Holtkötter, Jan Vermeer. 1 January 2006

(Reviewed by the Great Ape TAG, 2 July 2018)

4.6 Appendix VI: Practical guide for the collection of urine samples from chimpanzees for monitoring female reproductive status

Dr. Michael Heistermann

Dr. Michael Heistermann, Endocrinology Laboratory, German Primate Centre,
Leibniz Institute for Primate Research, Kellnerweg 4, D-37077 Göttingen, Germany.

General background

Breeding great ape species in captivity is a major objective of most zoos worldwide. Husbandry and breeding management can benefit largely by objective and reliable methods that allow female key reproductive processes to be monitored or diagnosed, such as ovarian activity (i.e., the presence of ovarian cycles with ovulation) and pregnancy. However, **irrespective of whether breeding is wanted or not, monitoring of female reproductive status can be used to either help to enhance or to avoid pregnancy.**

In this respect, the analysis of hormones from blood or their metabolites from excreta (urine, faeces) has shown to be of particular value given that all reproductive processes are regulated by hormones.

What are the main hormonal changes during an ovarian cycle and pregnancy?

The mammalian ovarian cycle consists of a follicular and luteal phase, both of which are associated with the secretion of specific hormones (Fig. 1). The follicular phase is characterized by the development of several follicles of which in primates usually only one, the dominant follicle, grows until ovulation. This process is accompanied by the secretion of oestrogens by the developing follicle (Fig. 1). At ovulation the dominant follicle ruptures and releases the oocyte which, in case of copulations, may be fertilized by a sperm, and a pregnancy is initiated. After ovulation, the luteal phase of the ovarian cycle begins and the ruptured follicle transforms into an active endocrine gland, the corpus luteum (CL; Fig. 1). The CL secretes increasing amounts of progesterone (Fig. 1), a hormone that prepares the uterus to support a possible pregnancy.

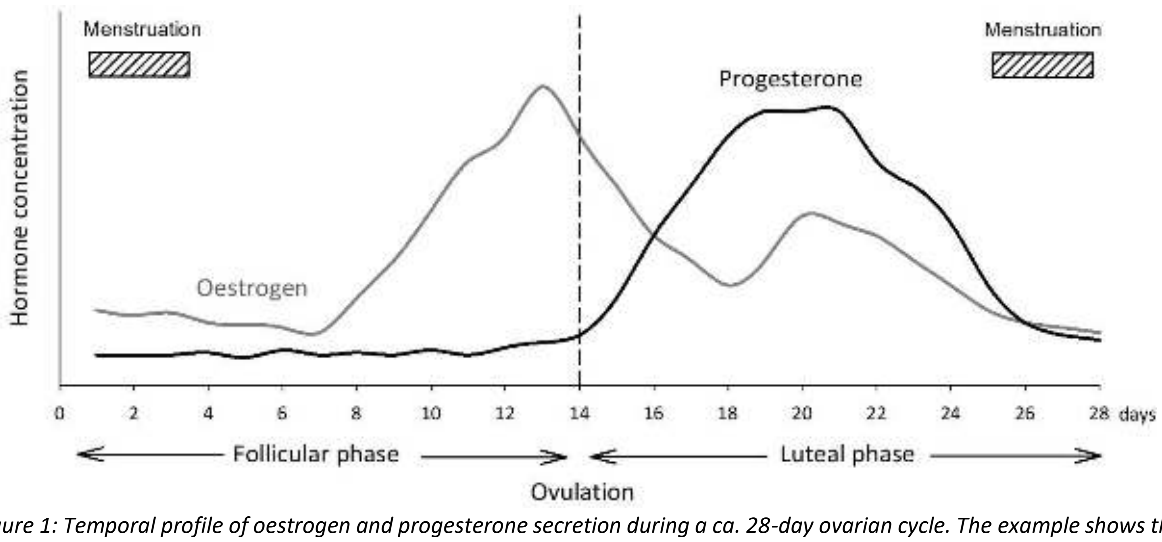


Figure 1: Temporal profile of oestrogen and progesterone secretion during a ca. 28-day ovarian cycle. The example shows the hormonal patterns in the human, but a generally similar pattern is seen in all mammal species.

In case fertilization of the oocyte does not occur, the CL regresses, progesterone levels decline (Fig. 1) and a new follicular phase starts, marking the onset of a new ovarian cycle which, in certain primate species (e.g., great apes), is also indicated by the presence of menstruation, like in humans.

If a pregnancy is initiated, progesterone

secretion by the CL and elevated progesterone concentrations are maintained to hormonally support the pregnancy and menstruation does not occur. **Thus**, **by monitoring the temporal pattern of progesterone secretion over time, reliable information on whether a female is regularlycycling, if and when ovulation occurred and if the female might have become pregnant can be obtained**.

How can the hormonal dynamics be monitored?

As all hormones exert their action via circulating in the blood, their measurement in blood is the most direct option to obtain information on their temporal dynamics. However, since **a reliable monitoring of ovarian activity needs repeated sampling** (at least 3 samples a week), the frequent collection of blood for hormonal monitoring is usually not an option in zoo-housed primates. Because circulating hormones are metabolised andtheir metabolites excreted into the urine and faeces, **the non-invasive measurement of hormone metabolitesfrom excreta is a reliable alternative to blood hormone measurements.**

Given the very clear temporal changes in progesterone during the ovarian cycle and pregnancy (see above), thedetermination of reproductive status in female primates is best achieved by the measurement of progesterone or its metabolites. For great ape species, including the chimpanzee, **the urinary measurement of pregnanediolglucuronide (PdG), the major metabolite of progesterone, is the most reliable, fastest and most cost-effective way for obtaining detailed information on female reproductive state**. Oestrogen (metabolite) measurements have also some value, but because their pattern is more variable and does not inform about whether ovulationhas occurred or not, it should not be measured singly, but can be determined to support PdG measurements ifmore complete information on the hormonal dynamics of the animal under study is wanted.

Urine samples can also be examined by zoo staff for the presence of blood using dip-stick tests. This allows menstruation days to be detected which, in turn, can provide a first estimate of whether a female is showing regular ovarian activity or not. Also, in chimpanzees the regular presence/absence of anogenital swelling provides a good indication of whether a female is likely to be showing cyclic ovarian activity or not. Last but not least, commercially available test kits designed to diagnose human pregnancy from urine based on the detection of chorionic gonadotropin (HCG), a hormone specifically secreted during early-to-mid pregnancy, usually also work well to diagnose pregnancy in great ape species from earliest about 3 weeks to latest about 3-4 months following conception. Here, repeated tests should be undertaken to ensure a reliable diagnosis.

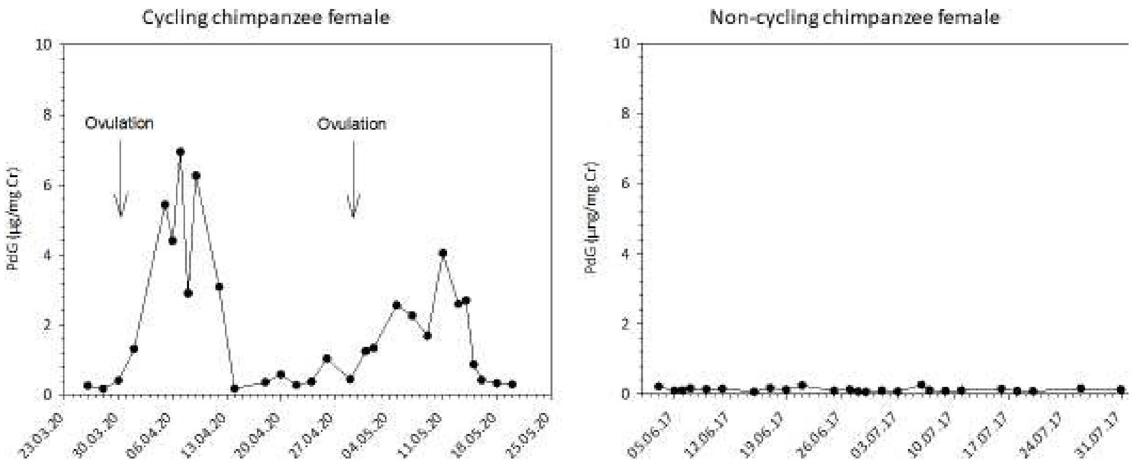
How should urine samples be collected for hormone analysis?

Urine can possibly be collected in various ways depending on keeping and housing system. The most importantrequirement for any sample collection protocol is that it is known which animal the sample came from. Thus, animals need to be observed for urination or need to be separated from other group members to facilitate sample collection.

In order to obtain well interpretable results on female reproductive state, **samples need to be collected at least every second day for a period of minimum 6 weeks,** a period that spans 1.5 ovarian cycle length of the ca. 30-day ovarian cycle common in chimpanzees. This allows to diagnose whether a female is cycling and ovulating or not and may also allow to diagnose a pregnancy in case the animal has conceived early during the sampling period.

The Endocrinology Lab at the German Primate Centre (DPZ) in Göttingen, Germany (https://www.dpz.eu/en/unit/endocrinology-laboratory/about-us.html), offers an endocrine diagnostics service to assess the reproductive status and/or confirm and monitor pregnancy by the measurement of progesterone and oestrogen metabolites from the urine (and partly also faeces) of all great ape species, including the chimpanzee.

The figure below provides an example of the urinary PdG profiles in a female chimpanzee showing regular ovarian cyclicity with the occurrence of ovulations (left) and a female which does not show ovarian cycles (right), indicating infertility during the sampling period.



If you are interested to make use of the DPZ´s endocrine service, **here are the details on how urine samples should be collected, labelled, stored and shipped** for hormonal analysis.

Collection of urine

- Collect the sample as fresh as possible.
- Collect only samples that are not contaminated with faecal material or material from anotherindividual.
- Also avoid contamination of the sample with water (e.g., from cage cleaning) as this may render thesample too dilute for analysis.
- A volume of 0.5 ml of urine is sufficient for the combined analysis of progesterone and estrogenmetabolites. If the collected volume is less than 0.5 ml, please still collect the sample and don´t discard it because samples can usually be diluted prior to analysis.
- Aspirate sample (using a pipette or syringe) from the floor enclosure or other surface and transfer itinto a plastic collection tube (e.g., 2 ml tube).
- Leave room in the tube for expansion of the sample during freezing (i.e., fill 2 ml tube with maximally

  1.5 ml of urine).
- Label the tube/container properly with running number, animal ID and date of

collection using an adhesive label which should be additionally protected with adhesive tape. It is most annoying if thelabelling comes off during freezing/transport/thawing or is no longer readable and thus practically lost for analysis.

- For practicality of analysis in the lab, it is important that each tube has a unique running number (onthe labelling and, if possible, also on the top of the tube lid), i.e., that there is no duplication in numbers in your sample set as this may raise confusion.
- Freeze sample in a regular freezer (-18°C) as soon as possible after collection (latest within 4 hours)for long-term storage. Hormone concentrations in samples left exposed to the environment for extended periods will increase the risk of hormone degradation and incorrect values.
- It is recommended (but not obligatory) to store samples in cryoboxes with a grid system. Ideally use agrid of 9x9, this provides enough space for 2 ml tubes and is sufficient for storing 81 samples in one box.
- If samples from more than one animal are collected, it helps if samples may already be sorted byanimal ID when storing them, i.e., prepare one box or one bag for each study animal.
- Prepare a sample collection list (i.e., excel file) for cross-checking purposes and recording of relevantinformation and notes.

Shipping of urine samples

For shipment of urine samples, you need to follow the packing guidelines for shipping dangerous goods, "Biological Substance, Category B", according to UN3373. You can find the respective guidelines in the internet or can ask the shipper of the samples (e.g., TNT, FedEx, DHL) about their specific regulations. Most importantlyyou have to **make sure that no urine will run out** of the package and that the tubes are not broken during transport (glass tubes should not be used at all!). It is usually requested that sample tubes should be packed into plastic bags and that absorbent material (i.e., paper) is placed into the shipping box to ensure that in case breakage does occur accidentally, the urine will be retained in the plastic bag or absorbed by the paper. Please also follow the following guidelines:

- Contact us first, prior to shipment, to be sure someone will be on hand to receive the samples.
- Please ship only Monday-Wednesday so samples will definitely arrive on a weekday (latest by Friday 2p.m.).
- All samples should be shipped frozen using frozen cold packs or dry ice to keep samples cold duringtransport.
- Make sure that shipment will be completed within 48 hours. Using an overnight express courierservice (e.g., DHL, FedEx) is highly recommended.

For any further questions on sample handling and shipment contact Dr. Michael Heistermann (Headof the Endocrinology Lab).