Management of Gorillas in Captivity

Husbandry Manual
Gorilla Species Survival Plan

Editors: Jacqueline Ogden, Zoological Society of San Diego
Dan Wharton, Wildlife Conservation
THE MANAGEMENT OF GORILLAS IN CAPTIVITY

Edited by:

Jackie Ogden, Ph.D.; Dan Wharton, Ph.D.
With special thanks to:

K. Worley
C. Jendry

Survey preparation and distribution by:

J. Rafert

Data analysis by:

K. Burks

Reviews provided by:

anonymous reviewers

Funding provided by:

Zoological Society of San Diego
Zoo Atlanta
Columbus Zoo

Copyright © Gorilla Species Survival Plan
AUTHORS

Beth Armstrong, Gorilla Department, Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive, Powell, OH 43065-0400

Cynthia Bennett, Ph.D., Research Zoologist, Dallas Zoo
621 East Clarendon, Dallas, TX 75203

Melanie Bond, Zoologist, National Zoological Park
3000 Block Connecticut Ave NW, Washington, DC 20008

Thaya duBois, Assistant Director of Research, Los Angeles Zoo
5333 Zoo Drive, Los Angeles, CA 90027

Kyle Burks, Research Associate, Zoo Atlanta
800 Cherokee Ave SE, Atlanta, GA 30315

Nancy Czekala-Gruber, CRES - Endocrinology Division, Zoological Society of San Diego
P.O. Box 551, San Diego, CA 92112-0551

Ellen Dierenfeld, Ph.D., Nutritionist, Bronx Zoo/Wildlife Conservation Park
2300 Southern Boulevard, New York, NY 10460-1099

James Doherty, General Curator, Bronx Zoo/Wildlife Conservation Park
2300 Southern Boulevard, New York, NY 10460-1099

Nilda Ferrer, Registrar, Bronx Zoo/Wildlife Conservation Park
2300 Southern Boulevard, New York, NY 10460-1099

Kenneth Gold, Ph.D., Director, Lincoln Park Zoo Gorilla Project
Lincoln Park Zoo, 2200 North Cannon Drive, Chicago, IL 60614-3895

Michael P. Hoff, Ph.D., Adjunct Researcher, Zoo Atlanta
800 Cherokee Avenue SE, Atlanta, GA 30315-1440

Charlene Jendry, Conservation Outreach Coordinator, Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive, Powell, OH 43065-0400

Nevin Lash, Consultant/Designer, URSA International
366 Oakland Avenue, SE, Atlanta, GA 30312

Linda Lowenstine, Ph.D., Professor, Veterinary Medical Teaching Hospital, University of California, Davis, CA 95616

Terry L. Maple, Ph.D., Director, Zoo Atlanta
800 Cherokee Avenue SE, Atlanta, GA 30315-1440
Thomas P. Meehan, DVM, Veterinarian, Brookfield Zoo
3300 Golf Road, Brookfield, IL 60513

Lorraine Meller, Curator of Mammals, North Carolina Zoological Park
4401 Zoo Parkway, Asheboro, NC 27203-9416

Jackie Ogden, Ph.D., Children's Zoo Curator, Zoological Society of San Diego
P.O. Box 551, San Diego, CA 92112

Lynn Patton, CRES - Endocrinology Division, Zoological Society of San Diego
P.O. Box 551, San Diego, CA 92112

Lindsay Phillips, Jr., D.V.M., Veterinarian, Sacramento Zoo
3930 West Land Park Drive, Sacramento, CA 95822-1123

Dave Popovich, Ph.D., Department of Nutritional Sciences, Faculty of Medicine,
University of Toronto, Toronto M5S 1A8, Canada

Ingrid Porton, Curator of Primates, St. Louis Zoological Park
Forest Park, St. Louis, MO 63110

Oliver Ryder, Ph.D., CRES Geneticist, Zoological Society of San Diego
P.O. Box 551, 2920 Zoo Drive, San Diego, CA 92112-0551

Marty Sevenich, Animal Training, Brookfield Zoo
3300 Golf Road, Brookfield, IL 60513

Rob Shumaker, Ape Keeper, National Zoological Park
3000 Block Connecticut Ave NW, Washington, DC 20008

Susy Steele, Mammal Technician, Dallas Zoo
621 East Clarendon, Dallas, TX 75203

H. Dieter Steklis, Ph.D., Rutgers University, Department of Anthropology
P.O. Box 270, New Brunswick, NJ 08903-0270

Stephanie Snowden, Keeper/Trainer, Brookfield Zoo
3300 Golf Road, Brookfield, IL 60513

Violet Sunde, Woodland Park Zoological Park
5500 Phinney Avenue North, Seattle, WA 98103

Rob Sutherland, Keeper, Calgary Zoo
P.O. Box 3036, Station "B", Calgary, Alberta, Canada T2M 4R8
Virginia Wall, Curator/Horticulture, North Carolina Zoological Park
4401 Zoo Parkway, Asheboro, NC 27203-9416

Meg White, Keeper, St. Louis Zoological Park
Forest Park, St. Louis, MO 63110

Jacqueline Zdziarski, DVM, Veterinarian, Brookfield Zoo
3300 Golf Road, Brookfield, IL 60513
THE MANAGEMENT OF GORILLAS IN CAPTIVITY

TABLE OF CONTENTS

Introduction, D. Wharton ............................................................................................................... 1
Natural History Overview ............................................................................................................. 5
  Gorilla Taxonomy, O. Ryder ............................................................................................. 7
  Distribution and Status of Wild Gorilla Populations, H.D. Steklis .................................. 11
  Social Structure - Overview, K. Gold ............................................................................. 15
Behavioral Biology ....................................................................................................................... 17
  Group Size and Composition, K. Gold ........................................................................... 19
  Abnormal Behaviors in Captive Gorillas, M. Hoff, K. Burks, T.L. Maple ...................... 26
  Adolescent Development, T. duBois ............................................................................. 35
  Estrous Cycle and Copulation, L. Patton, J. Ogden, N. Czekala-Gruber ....................... 39
  Gestation and Parturition, L. Patton, J. Ogden, N. Czekala-Gruber ............................... 45
  Infant Development and Parental Behavior, T. duBois .................................................... 51
Birth Control Options for Gorillas, I. Porton ............................................................................. 77
Care ............................................................................................................................................... 85
  Caregiver and Gorilla Relationship, M. White, B. Armstrong, R. Sutherland, R. Shumaker, V. Sunde ......................................................................................................................... 87
  Implementation of Positive Reinforcement Training, S. Snowden, M. Sevenich ............ 92
  Gorilla Enrichment, R. Shumaker ................................................................................ 102
  Birth Management and Hand-Rearing of Captive Gorillas, I. Porton ....................... 111
  Introductions and Socializations in Captive Gorillas, J. Ogden, I. Porton, K. Gold, C. Jendry ................................................................. 124
  Keeper Safety, J. Doherty ................................................................................................. 131
  Dangerous Animal Escapes, J. Doherty ........................................................................ 133
  Nutrition, D. Popovich, E. Dierenfeld ........................................................................... 138
  Cleaning and Routine Maintenance, M. Bond .................................................................. 147
Health ........................................................................................................................................... 151
  Disease Concerns in Lowland Gorillas, T. Meehan ...................................................... 153
  Causes of Mortality in Captive Lowland Gorillas, T. Meehan, L. Lowenstein ............ 160
  Preventive Medical Program for Captive Gorillas, L. Phillips, Jr. ......................... 181
  Zoonotic Diseases, T. Meehan, J. Zdziarski ................................................................. 191
  Immobilization and Shipping, T. Meehan ..................................................................... 197
  Transportation Standards ................................................................................................. 202
  Shipping and Regulations, N. Ferrer ............................................................................. 209
Design, N. Lash, J. Ogden, L. Meller, V. Gunn ................................................................. 217
Behavioral Research, C. Bennett, S. Steele ........................................................................... 267
Bibliography, Compiled by S. Steele, J. Ogden ................................................................... 287
Appendix: Directory of Advisors, Compiled by Gorilla Behavior Advisory Group ........ 379
INTRODUCTION

D. Wharton

The Management of Gorillas in Captivity is an attempt to bring together the collective expertise and opinion that goes into the everyday care of the world's largest primate. While most zookeepers, curators, veterinarians, and directors may know the literature and the networks for keeping current with the latest in gorilla husbandry, new professionals to the scene often inquire about a single reference for quick orientation to "the gorilla story." It is hoped that the Manual will fill that need.

The maintenance of gorillas in captivity has never been taken for granted. Earlier in this century, the process of keeping even a single specimen alive was still a mystery and was even declared an impossibility (Hornaday, 1922). Our predecessors would be surprised indeed to see the statistics of our most recent annual report (Wharton, 1994), which shows a breeding population of more than 300 animals, which further increases by several percent each year. This extremely positive picture came in small steps in the form of more insight into nutrition, housing, veterinary care, and social management from about 1930 through 1980. A major, critical step, which coincided with the shift into positive population growth, came with the establishment of the American Association of Zoos and Aquariums' (AZA) Gorilla Species Survival Plan (SSP) in 1982.

The SSP was developed by the members of the AZA to provide a scientific and quantifiable basis for captive conservation efforts (Meritt, 1980; Weise et al., 1991). Consensus, analysis, and observation all go into the development of a SSP, but ultimately the goals of the program must be translated into a series of "mini-goals" for each institution and each animal in the captive population. Annual recommendations for each animal must be carefully formulated, looking at program goals, institutional concerns, and animal status, all at the same time.

To the uninitiated, the long-term management of a captive population may sound either too simple or too complex. Some believe it is only a matter of putting males and females together and letting nature "take its course." Others recognize that a number of variables impact captive species management and wonder how genetics, age, temperament, social groupings, ownership, fertility, and/or litter size can all be accounted for in a given recommendation. The answer is, of course, that the process takes considerable work. It requires a detailed understanding of gorilla biology plus detailed fact-finding on every individual in the SSP population.

Some of the details of gorilla biology are well-known from field and captive studies. Others must be teased from demographic and genetic analyses of studbook data or, in certain cases, must be the subject of specific research efforts to fill in missing facts. In addition, captivity imposes certain constraints on managers, constraints that influence the ultimate size of the captive population and the speed at which recommendations can be implemented. The SSP
Gorilla Masterplan, completed in 1988 and revised yearly (e.g. Wharton, 1995), defines specific goals that must be met within biological and managerial limits under which the nearly 50 institutional participants must operate.

This manual is based on a thorough review of the relevant literature, including a number of unpublished reports and observations. Also included are data from a survey sent to institutions housing gorillas in North America. Out of a total of 49 surveys sent, 39 were returned, for a response rate of 79.6%. We extend our appreciation to those individuals who completed these surveys. A copy of the survey may be obtained by writing to Jan Rafert, Milwaukee County Zoo.

We recognize that there is much yet to be learned about this fascinating species, but as managers, we must make decisions with a finite set of facts laid before us. And, as always, two or more heads are better than one. The following chapters are written by many of the leaders in the continually developing and exciting business of caring for gorillas. They elaborate on the variables that contribute to the physical, psychological, demographic, and genetic health of the current captive population.

**MASTERPLAN SUMMARY**

Specific program goals include:

1. To attain, and then maintain, a stable population. To recruit seven newborn males and seven newborn females each year. (Tables 1 and 2 provide demographic and genetic summaries of the North American population as of 1992.)

2. To breed for the first time at least 2 and preferably 3 captive-born females and 2 captive-born males between the ages of 6 and 17 each year.

3. To try to induce reproduction of wild-born animals that have not yet bred.

4. To produce a minimum of 2.2 offspring from each founder and 1.1 from each individual in successive generations.

5. To maintain gorillas in social groups of at least 1.2 adults and facility collections of 2.3 adults, and allow for at least 1 juvenile per female.

6. To provide for proper socialization of handreared young, preferably in groups of three like-aged animals while small and in age-graded groups as early as possible.

In briefer summary, the Masterplan directs us to:

1. Assemble large, complex social groups.

2. Ensure peer-, mother-, and/or group-rearing of all juveniles.

3. Maximize male-female compatibility and reproductive opportunity.
4. Accomplish the above via animal transfer where necessary.

Table 1. Western Lowland Gorilla SSP Demographic Summary

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>16.557</td>
<td>16.402</td>
<td>17.284</td>
</tr>
<tr>
<td>Females</td>
<td>15.325</td>
<td>15.312</td>
<td>15.287</td>
</tr>
<tr>
<td>Population Rate of Increase (r)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>-0.010</td>
<td>0.010</td>
<td>0.014</td>
</tr>
<tr>
<td>Females</td>
<td>-0.015</td>
<td>0.005</td>
<td>0.018</td>
</tr>
<tr>
<td>Population Growth Rate (lambda)</td>
<td>1.04</td>
<td>1.04</td>
<td>1.04</td>
</tr>
</tbody>
</table>

25 May 1992

Table 2. Western Lowland Gorilla SSP Genetic Summary

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>1982</th>
<th>% DIFF</th>
</tr>
</thead>
<tbody>
<tr>
<td># Founders</td>
<td>106</td>
<td>82</td>
<td>+29</td>
</tr>
<tr>
<td>Founder Genome Equivalents</td>
<td>44.377</td>
<td>36.613</td>
<td>+21</td>
</tr>
<tr>
<td>Fraction of Wild Gene Diversity Preserved</td>
<td>0.989</td>
<td>0.986</td>
<td>+.03</td>
</tr>
<tr>
<td>Mean Inbreeding Coefficient</td>
<td>0.004</td>
<td>0.006</td>
<td>-33</td>
</tr>
<tr>
<td>Descent Population Mean Kinships</td>
<td>0.0111</td>
<td>0.0136</td>
<td>-18</td>
</tr>
</tbody>
</table>
Three subspecies of gorillas are currently recognized (Groves, 1970). Western lowland gorillas (*Gorilla gorilla gorilla*) inhabit several west central African countries, centering on Cameroon and Gabon. Eastern lowland gorillas (*Gorilla gorilla graueri*) are found in eastern Zaire, and mountain gorillas (*Gorilla gorilla beringei*) are found half in the Virunga volcanoes region of Rwanda, Uganda, and Zaire and half in the Bwindi Forest within Uganda, also known as the Impenetrable or Kayonza Forest.

Wild gorilla populations in many areas are diminishing due to habitat loss and poaching. Recently, mountain and eastern lowland gorillas were classified by the IUCN as endangered, while western lowland gorillas were considered threatened (Lee et al., 1988). Using current criteria, the IUCN recently downgraded the status of mountain gorillas to threatened (Groombridge, 1993).

The western lowland gorillas are separated from the east central African populations by approximately 1,000 kilometers, and these two major groups can be distinguished by a number of morphological characteristics (Groves, 1970). The mitochondrial DNA D-loop hypervariable sequence comparisons clearly reflect the western lowland/eastern gorilla separation. Assuming equivalent rates of mutation, genetic distances within these gorilla subspecies' range as high as those seen between chimpanzees and bonobos.

Although clear geographic and morphological distinctions are seen between the western lowland gorillas and the two eastern subspecies, within eastern gorillas identification of subpopulations has been subject to changing interpretations (reviewed in Groves, 1970). Studies of individual populations in Zaire, Rwanda, and Uganda have led to the recognition of two subspecies, eastern lowland and mountain gorillas (Groves, 1970). However, identification of individual eastern subpopulations is still complicated by morphological intergradations and some classifications have been debated recently. In different studies, the Kahuzi-Biega and Bwindi Forest populations have each been classified as both eastern lowland and mountain gorillas (Groves, 1970; Casimir, 1975; and Groves and Stott, 1979). Presently, however, the Kahuzi Biega population is considered to be eastern lowland, and the Bwindi Forest population is included with the mountain gorillas. The Virunga Volcanoes gorillas are considered the type *G. g. beringei* population. Mitochondrial DNA sequence comparisons of the Virunga, Kahuzi-Biega, and Bwindi Forest populations support the above current classification of the two populations in question. The Bwindi Forest sequences overlap with or differ only slightly from the Virunga sequences.

The mountain gorillas living in the Virunga Volcanoes region have been studied extensively in the wild since 1959 (Schaller, 1963; Fossey, 1983; many others), and their isolation and low numbers have caused concern that the population is at risk for inbreeding. Observation of lineages exhibiting strabismus and syndactyly (Fossey, 1983) have strengthened that concern.
Results from a recent study assessed genetic variability in and between these populations. Genetic samples in this study included animals from each wild population, as well as from captive lowland gorillas. The mtDNA variability found in this study is quite low within the Virunga population, and similarly low in the neighboring but separate Bwindi Forest population. An effort was made to select samples from several family groups from different locations within the two gorilla preserves. Even so, only 4 mtDNA types were found upon sequencing DNA from 29 individuals, and these types differed by only 1 to 4 transition changes within 250 basepairs.

Thus, our study supports the phylogenetic grouping of the Virunga and Bwindi Forest populations into a single taxonomic entity for purposes of conservation management. The suggestion of morphological variation between the two mountain gorilla populations (Butynski, personal communication; Groves, 1970; Groves and Stott, 1979) is intriguing, given the apparent negligible genetic distance between them based on mtDNA D-loop variation. Additional genetic studies and detailed investigations of morphological variation are indicated.

In 1976, when the Virunga Volcanoes mountain gorilla population was decreasing rapidly as a result of poaching and habitat loss, a proposal was made to supplement that population by translocation of gorillas from the Kahuzi-Biega population (MacKinnon, 1976). The translocation proposal was refuted (Harcourt, 1977), with the argument that gorilla social structure would make it unlikely that introduced individuals could assimilate into the breeding pool, and also that the Kahuzi-Biega habitat was sufficiently different that the Kahuzi-Biega gorillas would be poorly adapted for the Virunga Volcanoes region. The lack of overlap between mtDNA sequences of the Kahuzi-Biega gorillas and those of the mountain gorilla suggests that the populations are distinct enough that translocations between the two populations should not be considered. On the other hand, the mtDNA genetic distance between these two subspecies--about 6 percent transitions and 0.4 percent transversions--is much less than that within the western lowland gorillas, which are considered as a single breeding pool in zoo management programs.

The Kahuzi-Biega sequences form a clade that is related to but distinct from the Virunga sequences, supporting their distinction from the Virunga population. However, more eastern gorilla populations need to be sampled to verify this finding. It is possible that additional eastern lowland clades exist, and that the Kahuzi-Biega population could cluster outside the rest of the eastern lowland population.

The most divergent western lowland gorilla sequences in this study are from captive individuals who did not reproduce. However, one male in the study bred successfully with a female whose sequence differed by 7 % transition and 0.4 % transversion nucleotide changes. Another male bred successfully with two females whose sequences differed from his by 4 % and 5 % transitions respectively. Comparison of mtDNA sequences from additional successful captive breeding pairs might indicate what if any relationship exists between mtDNA sequence variability and reproductive compatibility. This information would provide a basis for decisions regarding translocations between populations or subspecies should the need arise in the future.

Indications of high variability within the western gorillas have been seen in the genetic distances determined from morphometric data (Groves, 1970). However, observations of this variability have not led to proposals for further subdivision of the western lowland subspecies.
The very high mtDNA variability seen within the western gorillas in this study cannot be correlated with geographic location or morphological or behavioral differences because most of the western gorillas in this study were from captive populations. However, the methods described here could be useful for genetic studies in the future if information were needed for conservation planning or for investigations concerning population genetics of gorillas, past patterns of spread of the species, or understanding of such factors as barriers to migration.

APPLICATIONS FOR SUBSPECIES IDENTIFICATION

The Kahuzi-Biega eastern lowland population is slightly more variable than the mountain gorillas in that more sequence types were found in a smaller population sample. However, the mtDNA types in this population also appear to stem from a recent common ancestor, differing by 1 to 4 transitions within the same region. Likewise, limited data from gorilla samples collected recently in the wild indicates that variability within regional western lowland gorilla populations is not nearly as high as that seen in the subspecies as a whole. Four nest samples were collected along the border between Central African Republic and the Congo Republic. Of these, three yielded identical DNA sequences and the fourth sequence differed by one nucleotide change. Of five sequences obtained from recently captured gorillas in Gabon, three were identical and two others differed by two transitions.

DNA sequence information also may be useful for subspecies identification of individual captive gorillas. Recently this D-loop hypervariable sequence was used to determine the subspecies identity of an infant female gorilla confiscated from traffickers in Zaire. The sequence obtained from DNA isolated from shed hairs was identical to that of one of the eastern lowland gorillas from Kahuzi-Biega Preserve. A decision was made not to attempt to "repatriate" this individual to a wild eastern lowland gorillas group for several reasons. Social factors would make successful introduction into an existing group unlikely. In addition, the potential exists for disease transmission to wild gorillas. Introduction into a habituated group under observation would have disrupted long-term behavioral studies. The gorilla has been moved to the Antwerp Zoo, which has the only captive population of G. g. graueri. At this facility, the capability exists to gradually introduce this individual to the captive group.

More extensive sampling of wild gorilla populations is needed, but the possibility exists that mitochondrial DNA variability in gorillas show strong geographic structuring, with low variability within isolated populations and limited gene flow between populations. If that is the case, the low mtDNA variability within the mountain gorilla and Kahuzi-Biega eastern lowland gorilla populations may not be atypical.

SUMMARY

1. The Virunga and Bwindi populations are genetically similar enough to be managed as a single subspecies.
2. The Kahuzi-Biega ("eastern") population is genetically distinct enough to be treated separately from the Virunga and Bwindi ("mountain") populations.
3. The lowland gorilla population shows greater genetic variation within the subspecies than exists between mountain and eastern. This variability is difficult to interpret as most of the individuals were from captive populations.
Harcourt (in press) has provided the most comprehensive, up-to-date summary and analysis of gorilla numbers, distribution, and threats to their survival. Consequently, much of the material contained in this section is based on Harcourt's summary.

There are an estimated 125,000 gorillas (Gorilla gorilla) over a geographic range of approximately 500,000 km² in central Africa, although gorillas occur in only about one tenth of this range (Harcourt, in press). This is double the last estimate and is due largely to the discovery of gorillas in higher density and in more habitats in the Congo (Fay et al., 1989; Fay and Agnana, 1992; Mitani, 1992) and to recent censuses showing higher numbers in Central African Republic (CAR) (Carroll, 1988) and in Zaire (Mwanza et al., 1992; Yamagiwa et al., 1993).

Gorilla gorilla gorilla, the western lowland gorilla, comprises about 80 percent of all gorillas. The total population of this species is currently estimated at 110,500 (Harcourt, 1995, in press). This subspecies is found in six countries: Central African Republic, Congo, Gabon, Equatorial Guinea, Cameroon, and Nigeria. The largest concentrations are in Gabon (43,000) and Congo (44,000). Conservation areas in these two countries are partly contiguous with those in CAR, Equatorial Guinea, and Cameroon. The known easternmost range of this subspecies has recently been extended to the Oubangui River in the Congo (Fay et al., 1989). Much of its former range north of southern Cameroon has been lost, although there is a small remnant population in Nigeria of about 100, which is considered "critically endangered" (Harcourt, in press) because of intense hunting and deforestation (Harcourt et al., 1989).

Gorilla gorilla graueri, the eastern lowland gorilla, has an estimated populations of 10,500 (Harcourt, in press), the distribution of which is restricted to eastern Zaire. There are two main conservation areas within its range: Kahuzi-Biega and Maiko National Parks, which together cover about 17,000 km². Gorilla habitat outside these conservation areas is highly fragmented.

Gorilla gorilla beringei, the mountain gorilla, with an estimated number of about 630 animals, is found only in conservation areas in two noncontiguous populations. One conservation area of 427 km², the "Virunga Conservation Area" (after Weber and Vedder, 1983), comprising a portion of the Virunga park in Zaire, the Volcanoes National Park in Rwanda, and the Mgahinga Gorilla Game Reserve in Uganda, contains about 310 mountain gorillas (Sholley, 1989). The second area, the Impenetrable (Bwindi) Forest in Uganda, just 25 km north of the Virunga area, contains another 320 mountain gorillas over an area of some 320 km² (Butynski, unpublished data).
ISSUES AFFECTING WILD POPULATIONS

For most wild gorilla populations, habitat loss due to human activity poses the greatest threat to their survival. For African countries with closed forests, including those that contain gorillas, the rate of forest clearance correlates significantly with human density (Harcourt, in press). Countries with gorilla habitat support their foreign debt through the exploitation of natural resources, such as logging, oil exploration, and mining (Harcourt, in press). Timber exports have increased threefold in the Congo, where over 40 percent of all western lowland gorillas live, and fivefold in Equatorial Guinea. In Cameroon, the Campo Reserve is currently being logged. In CAR, logging has claimed gorilla habitat in the southwest, but regrowth after logging may support higher gorilla densities (Carroll, 1988).

High population densities, particularly in Rwanda and Nigeria, have led to extensive forest clearing for agriculture. In Rwanda, Zaire, and Uganda, forest clearing has restricted mountain gorillas to two small, isolated populations that survive exclusively in well-protected conservation areas. In Nigeria, the remnant population of *G. g. gorilla* is divided into three to five isolated subpopulations, and continuing population growth is putting pressure on remaining gorilla habitat (Harcourt et al., 1989). The habitat of *G. g. graueri* in eastern Zaire has become increasingly fragmented and under pressure from humans. This subspecies is likely to persist only in protected areas.

The building of roads through previously isolated regions increases the rate of human
settlement and facilitates the procurement and transportation of timber from forests. For example, the newly completed Bangui-Douala Highway, which connects CAR to the coast, is likely to accelerate these processes in both the CAR and the Congo. Similarly, in eastern Zaire, a road under construction cutting through Kahuzi-Biega and touching Maiko National Park will increase access to these forests (Harcourt, in press).

Hunting pressure on gorilla populations varies with local custom and the level of protection of gorillas. In Nigeria, gorillas are eaten, and hunting pressure on them is high--so much so that deaths may exceed births (Harcourt, et al., 1989). Gorillas are also hunted for meat in parts of the Congo, Cameroon, Equatorial Guinea, and Zaire. In many of these areas, hunting pressure for meat is intensified by increased logging as timber workers hunt for bushmeat.

Until 1980, mountain gorillas were poached in Rwanda and Zaire, either to obtain heads and hands as trophies or to capture immatures for export (Fossey, 1983). Of the Virunga Conservation Area, the Rwanda sector has been consistently the best protected (Harcourt, 1986), with the result that a complete stop has been put to gorilla poaching in this sector. Unfortunately, in May 1995, four gorillas were speared to death by poachers in the Bwindi Park in Uganda. Although the smuggling of one or more immatures was suspected as a motive, this has not been verified. Similarly, in the Virunga sector of Zaire, three mountain gorillas--two silverback males and one female--were killed by poachers in August 1995, again with a presumed motive of abducting one or more immatures.

Part of the blame for the gorilla poaching in Zaire's Virunga Park is no doubt the political instability that has plagued the region since the beginning of Rwanda's civil war in October 1990. The unfortunate location of the Virunga Conservation Area along the border of Zaire, Rwanda, and Uganda has created difficulties for all three countries in conducting widespread antipoaching patrols on a consistent basis. Further, the involvement of this region in military conflict has posed additional, new dangers to the gorillas. For example, antipersonnel mines were laid throughout much of the Virunga forest beginning in October 1990, culminating in April 1994 as Rwanda fell to the Rwandese Patriotic Front. Periodic reports of gorillas killed by mines have remained unconfirmed, as it has not been possible to enter large segments of the mined forest. To date, one gorilla death has been confirmed as a direct consequence of military action.

Finally, the massive exodus of Rwandan refugees into Zaire, where they continue to live in large camps inside the Virunga park, poses new dangers to the region's mountain gorilla population. The presence of the refugee camps has led to the denuding of Park lands, increased game poaching in the Park, and continuing political instability in the region. To make matters worse, the resettlement of refugees into Rwanda will add to this country's population density crisis and will likely put additional pressures on the little remaining gorilla habitat. Indeed, if present trends continue, of all African countries that contain gorillas Rwanda is likely to see its remaining gorilla habitat disappear in the shortest amount of time--less than 25 years (Harcourt, in press).
ACKNOWLEDGEMENTS

I thank Ms. Wendy Birky for her assistance with the background research and preparation of this article. I also thank Dr. A. H. Harcourt for making available his data and analyses on the conservation status of gorillas.
K. Gold

The three subspecies of gorillas--mountain gorillas (*Gorilla gorilla beringei*), western lowland gorillas (*Gorilla gorilla gorilla*), and eastern lowland gorillas (*Gorilla gorilla graueri*)--all appear to have a similar social group structure, with the primary social structure referred to as a troop. Schaller (1963), Fossey (1983), and Harcourt (1979) established that most mountain gorillas live in cohesive troops led by a single dominant male (the silverback), a variable number of adult females, and immatures. Some multi-sex groups have more than one silverback. Both male and female gorillas tend to emigrate from their natal group upon reaching maturity. This serves to reduce inbreeding and increase genetic diversity in a species that tends to live in stable, long-lived social groupings. Exceptions to emigration do occur, as males occasionally remain in their natal group and eventually inherit group leadership from their fathers (Fossey, 1983). It is also apparent that some males, upon reaching sexual maturity, live alone or in bachelor groups of mature and maturing males (Harcourt, 1987). Lone silverback males have also been reported for the eastern lowland and western lowland gorilla subspecies.

Gorilla troop size in the wild reportedly varies between 3 and 42 members, with a mean between 7 and 14.7. Eastern lowland gorillas appear to have the largest troop sizes (range 3 to 42, mean 14.3), mountain gorillas have mid-range troop sizes (range 3 to 32, mean 9.15), and lowland gorillas have the smallest troop sizes (range 3 to 26, mean 7.2) (Yamagiwa, 1983; Stewart and Harcourt, 1987; Scholley, 1990; Aveling, 1995; Olejniczak, pers. comm.).

The strongest bonds appear to be between troop members and the silverback. The silverback’s role as a group leader has been documented by many authors (Schaller, 1963; Harcourt, 1979; Fossey, 1979, 1983). He serves as protector of the group and peacemaker during intergroup squabbles. The large degree of sexual dimorphism in gorillas, with adult males weighing twice as much as adult females, helps facilitate this dominance. The silverback is the center of the group focus and generally dictates the time and direction of the group’s movement. Young seem to congregate around the silverback, as do adult females. In groups with more than one silverback, one (generally the older one) assumes a more dominant position, while the other(s) remains somewhat on the periphery. Generally, only one silverback copulates with the adult females (Harcourt, 1979). Evidence of a female dominance hierarchy among mountain gorillas is disputed: Fossey (1983) claimed one directly based on length of time associated in a group, while Harcourt (1979) found no clear hierarchy.
BEHAVIORAL BIOLOGY

BEHAVIORAL BIOLOGY
GROUP SIZE AND COMPOSITION

K. Gold

IN THE WILD

Most of the data on gorilla social structure and demographics comes from studies conducted on mountain gorillas (*Gorilla gorilla beringei*) in Rwanda and Zaire by researchers at the Karisoke Research Centre. Sholley (1990) conducted the most recent census of mountain gorillas in the Virunga Volcanoes. Thirty-two groups comprising a total of 303 gorillas were counted by direct observation and/or nest site data, with an additional 6 solitary males noted. Group sizes range from 2 to 34 individuals, with a mean of 9.15.

Gerald (1995) reports on the Virunga Volcanoes database kept by Fossey and others on the research groups from September 1967 through September 1994, and on the tourist groups from October 1979 through September 1994. The mean group size for censuses taken in 1971 through 1989 are reported in Table 1. Census demographics indicate larger groups, primarily because of increased numbers of immature animals per group (Table 1).

Table 1. Virunga Mountain Gorilla Census Results (from Gerald, 1995).

<table>
<thead>
<tr>
<th>Census</th>
<th>No. of groups</th>
<th>Count in groups</th>
<th>Lone males</th>
<th>Mean Group Size</th>
<th>% Adult</th>
<th>% Immature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-73</td>
<td>31</td>
<td>246</td>
<td>15</td>
<td>7.9</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>1976-78</td>
<td>28</td>
<td>246</td>
<td>6</td>
<td>8.8</td>
<td>64%</td>
<td>36%</td>
</tr>
<tr>
<td>1981</td>
<td>28</td>
<td>237</td>
<td>5</td>
<td>8.5</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>1986</td>
<td>29</td>
<td>268</td>
<td>11</td>
<td>9.2</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>1989</td>
<td>32</td>
<td>303</td>
<td>6</td>
<td>9.1</td>
<td>55%</td>
<td>45%</td>
</tr>
</tbody>
</table>

The group sizes found for lowland gorillas appear smaller. Goldsmith (1995) has studied 5 different groups of western lowland gorillas (*Gorilla gorilla gorilla*) in the Central African Republic and reports that group size varies between 3 to 18 individuals, estimated by nest counts. Aveling (1995) reports group sizes of 1 to 26 (mean 7.2) for western lowland gorillas in northern Congo, based on nest counts. Olejniczak (1994) observed western lowland gorillas in the Noubale-Ndoki Reserve, Northern Congo. She reports observing 6 groups ranging from 5 to 14 individuals, each with a single silverback and 2 lone silverbacks. An additional group of eight gorillas encountered had two silverbacks. More recent observations by Olejniczak (pers. com., 1995) on 12 groups indicate that group size ranges from 5 to 14 individuals, with a mean group size of 7.3. Lone males were observed, but no bachelor groups have been observed at this study.
The group size and composition of western lowland gorillas in the Lope Reserve, Gabon, appear similar to those of the mountain gorillas of the Virungas (Tutin, et al., 1993), living in groups of 5 to 14 individuals with a median group size of 10 animals.

The apparent smaller group size of western lowland gorillas was reported by Stewart and Harcourt (1987), based on a review of published studies (Table 2).

Table 2. Demographic Parameters for Gorillas (from Stewart and Harcourt, 1987).

<table>
<thead>
<tr>
<th></th>
<th>Group Size</th>
<th>AM/Group</th>
<th>AF/Group</th>
<th>Imm/Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>Max</td>
<td>M</td>
</tr>
<tr>
<td>West</td>
<td>29</td>
<td>5</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>East</td>
<td>64</td>
<td>9</td>
<td>37</td>
<td>1</td>
</tr>
</tbody>
</table>

Most gorilla groups have a harem structure, with approximately 60 percent of mountain gorilla groups having only 1 adult male silverback and approximately 40 percent of groups containing more than 1 male (Stewart and Harcourt, 1987). Solitary mountain gorilla males make up approximately 10 percent of the population (Harcourt et al., 1981). Sholley (1990) reported that 23 of 32 groups contained 1 adult silverback, 7 groups contained 2 silverbacks each, and 1 group contained 4 silverbacks. The remaining group consisted of five blackbacks and one subadult female.

Yamagiwa (1983) reported that of the 12 groups of eastern lowland gorillas he surveyed, 10 had 1 silverback and 2 had 2 silverbacks. Olejniczak (1994) reports that out of 12 groups of western lowland gorillas observed, 1 group had 2 silverbacks, while Tutin et al. (1993) report that 2 of 8 groups they observed in Gabon had 2 silverbacks.

**HYPOTHESES FOR GROUP SIZE**

Several gorilla researchers have hypotheses about factors affecting gorilla social group size. Watts (1991) proposed that all residents may benefit by limiting group size, because this limits competition for food and increases each individual's access to males for protection and social contact. Stewart and Harcourt (1987) suggest that females live in groups for protection against predators and aggression from other gorillas. Yamagiwa (1983) suggests that group size may vary with the leading male's ability to maintain the group; i.e., to keep females. Goldsmith (1995) is exploring the hypothesis that in response to increased feeding competition based on their frugivorous diet, large groups of western lowland gorillas increase their group spread and/or fission into small temporary foraging parties. Tutin and her colleagues (1993) report that group size is positively correlated to home range size. They also report that western lowland gorillas travel further each day and have relatively larger home ranges that overlap extensively.
with neighboring groups than do gorilla populations elsewhere. They relate this to the frugivorous diet of the Lope gorillas.

MALE AND FEMALE EMIGRATION AT MATURITY

Both sexes usually disperse from their natal group, but females transfer directly to either another group or to a solitary silverback and never range by themselves (Stewart and Harcourt, 1987). Watts (1990) reports that of 14 females observed to reach sexual maturity in study groups, 7 remained in their natal group for their first birth (although in each case, the group contained at least 1 young, sexually active male who was not her father and with whom she copulated). Female natal group transfers probably function at least partly to avoid father/daughter inbreeding (Stewart and Harcourt, 1987). There are no known offspring of father/daughter matings in the wild, although Watts (1990) reports six observations of copulations between known fathers and daughters. Males, on the other hand, rarely join breeding groups. Harcourt (1978) reports 17 known transfers into bisexual groups, and only one (a blackback) was a male. Transfer of females generally occurs around age 8, and males emigrate at age 11 (Maple and Hoff, 1982). Male and female emigration has also been observed in *Gorilla gorilla graueri* in Zaire (Yamagiwa, 1983).

BACHELOR GROUPS

Usually, males emigrate from their natal group before they have bred, becoming solitary or joining (or forming) an all-male grouping. In the Virungas, all male groups may make up 10 percent of all groups at any one time (Stewart and Harcourt, 1987). No silverback (>13 years) has been observed attempting to enter an all-male group, but males from 6 to 13 years have joined all-male groups without serious aggression (Harcourt, 1988). Attraction of young emigrant, wandering males to each other leads to the formation of bachelor groups of unrelated males. Male groups can be stable for long periods of time (two to four years), with stability affected by the abilities of individual males to obtain females. Bachelor groups rarely contain many males in the prime of their life or older, because these animals have generally formed family groups (Harcourt, 1988). Once males reach an age to start seeking females and competing for them, and if they are not the resident dominant male, they depart the bachelor group and start to seek females alone. The arrival of females has a dramatic effect on the stability of the bachelor group. When females join, aggression increases and subordinate males often depart (Elliot, 1976). No bachelor groups have been observed for western lowland gorillas in the wild, although it should be noted that relatively little data have yet been collected on this subspecies in the wild.

MULTI-MALE GROUPS

In the Virungas, approximately 40 percent of groups contain more than 1 male (Stewart and Harcourt, 1987). It is likely that in many of these multi-male groups, the males are related. The likelihood of a male not emigrating from his natal group is related to the number of mature males already present, their relative ages (Harcourt, 1979), and the past history of the maturing male's relationship with other group males (Harcourt and Stewart, 1981). Observations of multi-male groups have been reported for western lowland gorillas by both Tutin et al. (1993) and
OLEJNIČZAK (1994; pers. com., 1995) in Gabon and Congo respectively.

SECONDARY FEMALE TRANSFER

To a certain extent, females will transfer to different groups even after reaching maturity. Nulliparous females sometimes transfer more than once before reproducing, and Watts (1991) reports at least 28 transfers by parous females in the Virunga study population. Individual parous females have been known to have transferred at least five times. Some transfers occurred following silverback deaths, but most involved emigrations from groups that included a mature silverback. There is evidence that females make choices about particular males with which to reside. Some of the known transfers have been between lone silverbacks or between groups with similar numbers of females, which suggests that the females were searching for the right male and not just responding to group size (Stewart and Harcourt, 1987). A possible preference for older and more experienced males has been suggested for mountain gorillas (Watts, 1985) and eastern lowland gorillas (Yamagiwa, 1983), yet Tutin and her colleagues (1994) suggest that females may be reluctant to join a group if the silverback is old. Harcourt et al. (1976) suggest that one of the factors involved in female choice is the quality of the male's range, and whether the female stayed or not was related to her success in raising offspring in the group.

Females often transfer between groups during intergroup encounters. Sicotte (1993), from her studies on mountain gorillas, proposes that encounters are related to the acquisition of females rather than to the defense of a group's range. Male herding behavior serves to prevent female transfer. Females without dependent offspring are more likely to be herded, and proceptive females are more likely to be herded than nonproceptive, cycling females. Stewart and Harcourt (1987) report that female transfer usually occurs when two groups or a group and a solitary male come into close proximity. While the males display and sometimes fight with each other, the female moves away from her group, approaches the new male, and then follows him when the encounter ends. They report that most females transfer at least once in their lives. Female transfer and male-male competition during intergroup encounters have also been observed in Gorilla gorilla graueri in Zaire (Yamagiwa, 1983).

THEORIES ON FEMALE DOMINANCE HIERARCHIES

Fossey (1983) reports that impressions of a female dominance hierarchy based on stable rank differences among nulliparous and parous females are generally not apparent. In three of four groups studied, no clear dominance hierarchy was determined, partly because frequency of supplants was so low. In the fourth case, there did appear to be a linear hierarchy between the four adult females (Stewart and Harcourt, 1987). In this case, the hierarchy was related to age, with no younger animal dominating an older one.

Adult females compete directly for food (Stewart and Harcourt, 1987). When related females live in the same group, they tend to treat relatives differently than nonrelatives. They spent more time in proximity to kin when feeding or resting, groomed kin more, were less aggressive towards them, and aided them more in agonistic encounters (Stewart and Harcourt, 1987; Watts, 1994). Watts (1994) reports that many female long-term residents of groups form
social cliques that are partly independent of relatedness, and both resist immigration attempts and maintain particularly unfriendly relationships with immigrants.

Yamagiwa (1983) observed that females with dependent young tend to stay near the leading male and to cluster with each other more often than females without offspring. Adult females (8+ years) interact little with each other and very little with blackbacks (Harcourt, 1979). Watts (1994) reported evidence of kinship links among adult females: more time in proximity to kin when feeding or resting, kin groomed more, less aggression between them. Adult females were attracted to the silverback, and those with young offspring spend more time in his proximity.

Mean age at first reproduction for female mountain gorillas is 10.22 years (Gerald, 1995). Females reproduced at a younger age in multi-male troops (9.9 years) than those in groups with only 1 silverback (11.1 years). Infants will stay close to their mothers for the first three to four years, often nursing for three years. When they become juveniles, females tend to stay near their female relatives or the silverback and show great interest in new infants in the group. Males tend to engage in more rough and tumble play and also continue to interact with the silverback until approaching blackback status. The rate of adult-adolescent male aggression increases as adolescents mature (Watts and Pusey, 1993).

GROUP FISSION AFTER DEATH OF SILVERBACK

Yamagiwa (1983) reports that when a group leader dies or is killed, the group can be reintegrated after his death by his successor. Should this not occur, often the group fissions after the death. Fossey (1983) speculated that no gorilla group can exist without its unifying force, the silverback.

Table 3. Range, Average and Standard Deviation of Age/Sex Classes Based on Survey responses for 32 Groups from 39 Institutions.

<table>
<thead>
<tr>
<th>AGE/SEX CLASS</th>
<th>Range</th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult male</td>
<td>0-2</td>
<td>0.68</td>
<td>0.57</td>
</tr>
<tr>
<td>Young adult male</td>
<td>0-1</td>
<td>0.11</td>
<td>0.32</td>
</tr>
<tr>
<td>Blackback male</td>
<td>0-3</td>
<td>0.34</td>
<td>0.82</td>
</tr>
<tr>
<td>Juvenile male</td>
<td>0-2</td>
<td>0.40</td>
<td>0.71</td>
</tr>
<tr>
<td>Infant male</td>
<td>0-2</td>
<td>0.17</td>
<td>0.45</td>
</tr>
<tr>
<td>Adult female</td>
<td>0-5</td>
<td>1.42</td>
<td>1.24</td>
</tr>
</tbody>
</table>
IN CAPTIVITY

In terms of size, composition, and social interaction, captive groups have been and continue to be very different from those in the wild. The size of groups held in captive environments varies from institution to institution. Groups range from pairs of animals to as many as 10, with the average group size being 4.45 individuals (s.d. = 2.01). Thirteen individuals were housed solitarily: 3 silverbacks, 3 adult females, 1 young silverback, 4 infant females, and 2 infant males. Table 3 provides the range, average, and standard deviation for the various age/sex categories. Under SSP management, few animals remain solitary for extended periods of time except aged animals with health problems.

As of January 1995, there were 148,172 animals in the SSP population. Figure 1 represents the age/sex pyramid for the living SSP population (Thompson, report to SSP, 1995). For females, the distribution is fairly even, while the male distribution is skewed towards younger males, with more than one half of the current male population (76 animals) under the age of 12.

Historically, gorillas were kept alone or in pairs. Larger groupings have primarily occurred since the early 1960s and initially consisted of peer groups of young animals maturing together. One of the goals of the SSP has been to assist in the building of species-appropriate social groups through SSP recommendations. Few institutions have been able to exhibit large groups of eight or more gorillas together, often due to space or resource limitations. However, because more is now known about natural gorilla group sizes, the trend is toward exhibiting animals in larger groups that approximate those of their wild counterparts. Exhibits are now being constructed to accommodate even larger groups for the future. The building of more
naturalistic social groupings should lead to more species-appropriate behavior.

SURVEY RESULTS

Of 65 groups in 39 institutions, the average amount of time with no change in group membership was 24.7 months (range 1 to 120 months). Of the 60 groups for which reasons were reported for change, 9 changes (15 percent) were due to births, 48 (80 percent) were due to transfers, and 3 (5 percent) were due to deaths. Institutions were also queried on the average amount of time each current group remained without a change in the silverback. Results for 50 groups demonstrated an average of 40.1 months (range: 1 to 144 months), with 2 additional groups having no change for 384 months and 396 months respectively. Of the 41 groups for which a reason for a change was reported, 29 (70.7 percent) reported the change as a result of the introduction of a new male, 7 (17.1 percent) as a result of the death of a silverback, 3 (7.3 percent) as the result of a change in dominance, and 2 (4.9 percent) as a result of a transfer.

Of the 39 institutions that answered the SSP survey, 35 report having only one silverback male per group (89.7 percent), while 4 report groups with more than one silverback (10.3 percent). In three of the four cases, the two silverbacks are of no blood relation, while in the fourth case the second male is the son of the silverback. Of the three that answered the query about one of the two males being dominant, all three reported a dominant silverback. Of these 3 institutions with 2 silverback groups, the length of time the two silverbacks had been together was 3 years, 7 months, years and 11 years, respectively.

When asked if one of the females maintains a dominant position in the troop, 21 of the 39 institutions answering indicated a dominant female (53.8 percent) (although the measure used to determine dominance was not reported).

Location of animals (holding, inside or outside exhibits) was reported to affect the frequency of aggression between males by 46.2 percent of institutions queried. Aggression amongst females was related to location according to 71.8 percent of institutions, and location was reported to effect male-female aggression by 56.4 percent of institutions. All three categories of aggression (male-male, male-female, and female-female) were reported highest in holding facilities when compared with levels in outside or inside exhibits.
Abnormal behavior in primates is typically defined as behavior that is aberrant or pathological, such as eating disorders (coprophagy, regurgitation, reingestion), stereotyped movements, hyperaggressivity, inappropriate sexual orientation, and bizarre posturing (Erwin and Deni, 1979). As applied to captive situations, this definition generally includes behaviors that vary in quality or quantity from behaviors seen in the wild. This is not to imply that all behaviors in the wild are "normal" or "appropriate." Certainly some individuals in the wild have been reported to engage in idiosyncratic, stereotyped motor behaviors (Fossey, 1983). For the purposes of this section, however, we will focus on behaviors seen in captivity. Further, there are behaviors that have been reported in wild gorillas—such as geophagia (eating of soil), and the eating of snails, ants, and termites (Fossey, 1983; Tutin and Fernandez, 1983; Watts, 1989; Mahaney, Watts, and Hancock, 1990; Yamagiwa, Yumoto, and Maruhashi, 1991)—that may cause concern if found in a captive population, yet they are considered normal in wild populations.

**STEREOTYPIC BEHAVIORS**

Stereotyped or aberrant individual behaviors have been reported in captive gorillas. Meder (1985) described rocking and swaying in a female infant, along with a stereotyped locomotion that was a "...kind of crawling with wood wool in her arms" that resulted in hairless spots on her forearms and hands. Meder (1989) also reported on a comparison of 19 hand-reared to 7 mother-reared gorilla infants. While no mother-reared infants exhibited these behaviors, almost all of the hand-reared infants did. Those behaviors included digit sucking, lip sucking, and rocking (back and forth and up and down). These behaviors generally declined by the third year of life, but the time spent engaged in stereotypies increased "strikingly" under stressful conditions (i.e. during introductions). Our colleague, Kristen Lukas (1995), noted individual adult gorillas at Zoo Atlanta exhibiting self-manipulation, self-clasping, and self-patting at high levels. Studying a different group of gorillas at Zoo Atlanta, we (Hoff, unpublished data) have found high levels of autogrooming in an adult female gorilla.

**APPETITIVE DISORDERS**

There are numerous instances of coprophagy and regurgitation and reingestion (R/R) reported in captive gorillas (e.g. Ruempler, 1992; Lukas, 1995). Akers and Schildkraut (1985) note that these are pervasive behaviors in captivity. Coprophagy has been reported in the wild (Harcourt and Stewart, 1978; Fossey, 1983); however, the frequency at which it occurs in captivity is much greater than that reported in the wild. R/R has not been reported in the wild. These authors present the results of their survey of 206 gorillas in 56 North American institutions that have gorillas. They found that more than half of the gorillas in responding
institutions exhibited coprophagy (65 percent of the females, 42 percent of the males). Additionally, 68 percent of the gorillas in responding institutions exhibited R/R, with more than half exhibiting this behavior once a day or more. They found rearing conditions were associated with R/R: 75 percent of the wild-born animals and 57 percent of the zoo-born animals engaged in this behavior.

These data are similar to the survey data of Gould and Bres (1986), in which 69 percent of the 117 gorillas surveyed from 17 different zoos engaged in R/R. Their data showed substantial age/rearing condition differences: 95 percent of the captive-born, hand-reared, 5-years-and-older animals engaged in this behavior, 50 percent of the captive-born, mother-reared animals did, and 85 percent of the wild-caught animals engaged in R/R. Of the 26 gorillas less than 5 years of age, only 19 percent showed R/R.

SOCIAL DISORDERS

One problem often resulting in serious consequences is that of inadequate maternal care, including rejection of and/or mutilation of the infant. This pattern of behavior commonly leads to separation and hand-rearing the infant (Maple and Hoff, 1982; Kawata and Elsen, 1984). In extreme circumstances, it can lead to the death of the infant (Benirschke and Adams, 1980). Although maternal neglect does occur in the wild, particularly among first-time mothers, it is more frequent in captivity. This is a complex behavior; for more information, see the birth management and infant development sections of this manual.

Problems in social behavior have been reported by several researchers. Brown and Wagster (1986) described gradual changes in a noninteractive adult female gorilla when three younger gorillas were introduced to her. Winslow, Ogden, and Maple (1992), of Zoo Atlanta, report on the socialization of a wild-born silverback male ("Willie B.") that had lived in social isolation from conspecifics for 27 years. "Willie B." has since fathered an offspring (Hoff et al., in press). Burks (in preparation) has studied another wild-born, isolate-reared silverback male ("Ivan"), also at Zoo Atlanta. (See sections on social behavior and birth management in this volume.)

RESULTS OF THE GORILLA HUSBANDRY SURVEY

Thirty-nine zoos responded to the Gorilla Husbandry Survey. Of those, 32 provided information concerning their total number of gorillas at the zoo. Data from those 32 are included in the overall analysis of observed abnormal behaviors (see following paragraph and Table 1). Data from all 39 institutions are included in the remaining analyses (see Tables 2 through 5).

Institutions reported the number of their gorillas that exhibited particular behaviors. We used the absolute numbers reported to calculate the percentage of the total population (N= 233) exhibiting particular abnormalities. Regurgitation and reingestion was the most commonly observed abnormal behavior, with more than half (53.65 percent) of the total population of gorillas of the responding institutions reportedly exhibiting this behavior. Likewise, coprophagy was very common, occurring in 36.91 percent of the total reported population. The overall
percentage of observed regurgitation (the survey distinguished between regurgitation and R/R) was slightly less than one quarter (24.03 percent) of the total reported population. Several other abnormal behaviors occurred at much lower levels overall, including "over-grooming self" at 7.73 percent, "thumb and/or finger sucking" at 6.87 percent, "rocking" at 4.29 percent, "over-grooming offspring" at 2.6 percent, and "pacing" at 1.3 percent. The remaining abnormalities on the survey were reported at some level, but showed overall low percentages ("self-biting" at 0.9 percent; "hitting head" at 0.4 percent; "over-grooming others" at 0.4 percent). Several other individual patterns of abnormal behaviors were reported by zoos, including covering ears (three zoos), fecal art (two zoos), and self-clasping (two zoos), among others.

After examining the range of behaviors reported overall, we calculated the percentage of individual gorillas within each zoo that exhibited given behaviors. Table 1 shows the mean, median, standard deviation, and range of those calculated percentages of reported abnormalities within zoos. Not only was R/R the most common behavior overall, but it was also widely dispersed throughout the responding zoos. Twenty eight of the 32 zoos included in the analysis reported observing R/R; the mean percent of gorillas at a zoo engaged in this behavior was 55.1 with a median of 52.2. Coprophagy was also widely distributed within zoos, averaging 39.6 percent of the gorillas in a collection, with a median of 33.3. Regurgitation was exhibited by a mean of 27.2 percent of the gorillas in a collection showing this behavior. The high standard deviation and 0.00 median of this behavior indicates that it was not as widespread around zoos (15 of 32 zoos reported this behavior occurring). As noted above, all of the remaining abnormalities listed on the survey were reported, but were scattered in their appearance at zoos. For example, pacing was reported at three zoos and involved one gorilla in each of those institutions (out of groups of six, nine, and nine gorillas, respectively).

Table 1: Reported abnormal behaviors within zoo populations of gorillas in percentages from the Gorilla Husbandry Survey. Data included are from the 32 zoos that provided total numbers of gorillas in their collection.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coprophagy</td>
<td>39.6</td>
<td>33.3</td>
<td>35.0</td>
<td>0.0-100.0</td>
</tr>
<tr>
<td>Hitting head/body</td>
<td>0.5</td>
<td>0.0</td>
<td>2.9</td>
<td>0.0-16.7</td>
</tr>
<tr>
<td>Over-groom offspring</td>
<td>2.0</td>
<td>0.0</td>
<td>5.5</td>
<td>0.0-25.0</td>
</tr>
<tr>
<td>Over-groom others</td>
<td>0.8</td>
<td>0.0</td>
<td>4.4</td>
<td>0.0-25.0</td>
</tr>
<tr>
<td>Over-groom self</td>
<td>8.6</td>
<td>0.0</td>
<td>13.6</td>
<td>0.0-50.0</td>
</tr>
<tr>
<td>Pacing</td>
<td>1.2</td>
<td>0.0</td>
<td>3.9</td>
<td>0.0-16.7</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>27.2</td>
<td>0.0</td>
<td>38.0</td>
<td>0.0-100.0</td>
</tr>
<tr>
<td>Regurg./Reingestion</td>
<td>55.1</td>
<td>52.2</td>
<td>36.8</td>
<td>0.0-100.0</td>
</tr>
<tr>
<td>Rocking</td>
<td>5.7</td>
<td>0.0</td>
<td>13.9</td>
<td>0.0-66.7</td>
</tr>
<tr>
<td>Self-biting</td>
<td>4.2</td>
<td>0.0</td>
<td>18.4</td>
<td>0.0-100.0</td>
</tr>
<tr>
<td>Thumb/finger sucking</td>
<td>5.9</td>
<td>0.0</td>
<td>10.6</td>
<td>0.0-50.0</td>
</tr>
</tbody>
</table>

Note: These data were obtained via surveys based on keeper collections, not on systematic behavioral observations, and thus may be either over or under estimates.
Zoos were asked about observed changes in abnormal behaviors associated with an individual being separated from the group. Of the institutions that reported on given behaviors, the most common finding for all behaviors was no change (Table 2). However, several behaviors were observed to increase in substantial percentages at various zoos, including R/R, coprophagy, finger/thumb sucking, over-grooming self, pacing, and rocking. There were far fewer observed decreases in abnormal behaviors associated with another individual being removed from the group.

Table 2: Reported change in abnormal behaviors associated with an individual being separated from the group (in percentages), from the Gorilla Husbandry Survey. Data included from all 39 responding zoos.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Increase</th>
<th>Decrease</th>
<th>No change</th>
<th>No answer/Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coprophagy</td>
<td>20.5</td>
<td>5.1</td>
<td>48.7</td>
<td>25.6</td>
</tr>
<tr>
<td>Hitting head/body</td>
<td>0.0</td>
<td>0.0</td>
<td>35.9</td>
<td>64.1</td>
</tr>
<tr>
<td>Over-groom offspring</td>
<td>0.0</td>
<td>2.6</td>
<td>28.2</td>
<td>69.2</td>
</tr>
<tr>
<td>Over-groom others</td>
<td>2.6</td>
<td>0.0</td>
<td>33.3</td>
<td>64.1</td>
</tr>
<tr>
<td>Over-groom self</td>
<td>17.9</td>
<td>0.0</td>
<td>30.8</td>
<td>51.3</td>
</tr>
<tr>
<td>Pacing</td>
<td>12.8</td>
<td>2.6</td>
<td>23.1</td>
<td>61.5</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>5.1</td>
<td>0.0</td>
<td>43.6</td>
<td>51.3</td>
</tr>
<tr>
<td>Regurg./Reingestion</td>
<td>25.6</td>
<td>0.0</td>
<td>53.8</td>
<td>20.5</td>
</tr>
<tr>
<td>Rocking</td>
<td>10.3</td>
<td>0.0</td>
<td>35.9</td>
<td>53.8</td>
</tr>
<tr>
<td>Self-biting</td>
<td>0.0</td>
<td>2.6</td>
<td>33.3</td>
<td>64.1</td>
</tr>
<tr>
<td>Thumb/finger sucking</td>
<td>20.5</td>
<td>0.0</td>
<td>30.8</td>
<td>48.7</td>
</tr>
</tbody>
</table>

Of the zoos answering the questions concerning such behaviors in relationship to location (inside exhibit, outside exhibit, holding area), the most common response was to show no change. However, several behaviors did show interesting changes associated with location. There was a greater increase in percentage of zoos reporting abnormal behaviors in the holding area location than the other two (Table 3). R/R (23.1 percent), thumb/finger sucking (20.5 percent), and coprophagy (18 percent) all showed marked percentage increases. Several other abnormal behaviors were also reported as increasing in the holding area location, but at lesser levels. Interestingly, coprophagy was reported as declining in the holding area location by 15.4 percent of the zoos. Only one other behavior (R/R) was reported as declining in this location, and it was only a minor change.

In the inside exhibit location (Table 4), almost one-third of zoos surveyed reported an increase in coprophagy. Likewise, R/R showed an increase in a substantial percentage of zoos (18 percent). There were smaller changes (both increase and decrease) in a number of other behaviors.
Table 3: Number of institutions reporting changes in abnormal behaviors when animals housed in a holding area location. Data from the 39 responding institutions in the Gorilla Husbandry Survey, expressed in percentages of institutions reporting on observed changes.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Reporting</th>
<th>Reporting</th>
<th>Reporting</th>
<th>No answer/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coprophagy</td>
<td>18.0</td>
<td>15.4</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Hitting head/body</td>
<td>0.0</td>
<td>0.0</td>
<td>25.6</td>
<td>74.4</td>
</tr>
<tr>
<td>Over-groom offspring</td>
<td>5.1</td>
<td>0.0</td>
<td>25.6</td>
<td>69.2</td>
</tr>
<tr>
<td>Over-groom others</td>
<td>0.0</td>
<td>0.0</td>
<td>25.6</td>
<td>74.4</td>
</tr>
<tr>
<td>Over-groom self</td>
<td>12.8</td>
<td>0.0</td>
<td>23.1</td>
<td>66.7</td>
</tr>
<tr>
<td>Pacing</td>
<td>7.7</td>
<td>0.0</td>
<td>23.1</td>
<td>69.2</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>12.8</td>
<td>0.0</td>
<td>30.8</td>
<td>56.4</td>
</tr>
<tr>
<td>Regurg./Reingestion</td>
<td>23.1</td>
<td>2.6</td>
<td>51.3</td>
<td>23.1</td>
</tr>
<tr>
<td>Rocking</td>
<td>5.1</td>
<td>0.0</td>
<td>38.5</td>
<td>56.4</td>
</tr>
<tr>
<td>Self-biting</td>
<td>0.0</td>
<td>0.0</td>
<td>28.2</td>
<td>71.8</td>
</tr>
<tr>
<td>Thumb/finger sucking</td>
<td>20.5</td>
<td>0.0</td>
<td>30.8</td>
<td>48.7</td>
</tr>
</tbody>
</table>

Table 4: Number of institutions reporting changes in abnormal behaviors when animals housed in an inside exhibit location. Data from the 39 responding institutions in the Gorilla Husbandry Survey, expressed in percentages of institutions reporting on observed changes.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Increase</th>
<th>Decrease</th>
<th>No change</th>
<th>No answer/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coprophagy</td>
<td>30.8</td>
<td>2.6</td>
<td>17.9</td>
<td>48.7</td>
</tr>
<tr>
<td>Hitting head/body</td>
<td>0.0</td>
<td>0.0</td>
<td>12.8</td>
<td>87.2</td>
</tr>
<tr>
<td>Over-groom offspring</td>
<td>0.0</td>
<td>0.0</td>
<td>15.4</td>
<td>84.6</td>
</tr>
<tr>
<td>Over-groom others</td>
<td>0.0</td>
<td>0.0</td>
<td>12.8</td>
<td>87.2</td>
</tr>
<tr>
<td>Over-groom self</td>
<td>5.1</td>
<td>0.0</td>
<td>17.9</td>
<td>79.5</td>
</tr>
<tr>
<td>Pacing</td>
<td>0.0</td>
<td>2.6</td>
<td>12.8</td>
<td>84.6</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>7.7</td>
<td>5.1</td>
<td>10.3</td>
<td>76.9</td>
</tr>
<tr>
<td>Regurg./Reingestion</td>
<td>17.9</td>
<td>5.1</td>
<td>33.3</td>
<td>43.6</td>
</tr>
<tr>
<td>Rocking</td>
<td>2.6</td>
<td>2.6</td>
<td>23.1</td>
<td>71.8</td>
</tr>
<tr>
<td>Self-biting</td>
<td>2.6</td>
<td>0.0</td>
<td>12.8</td>
<td>84.6</td>
</tr>
<tr>
<td>Thumb/finger sucking</td>
<td>0.0</td>
<td>2.6</td>
<td>17.9</td>
<td>79.5</td>
</tr>
</tbody>
</table>
The outdoor location (Table 5) was the only location where decreases in abnormal behaviors were reported by a substantial percentage of zoos. Both coprophagy (35.9 percent) and R/R (33.3 percent) showed striking decreases in reporting institutions in this location. There were also declines reported by smaller percentages of zoos in regurgitation, over-grooming self, rocking, and thumb/finger sucking, among others. Five behaviors did show increases in the outside exhibit location: coprophagy (7.7 percent) was the largest percentage increase reported.

Zoos were asked whether they had been successful in alleviating stereotypic behaviors in individuals and in groups. Zoos were much more successful with individuals than with groups. Among individuals, 51.3 percent of zoos indicated success (43.6 percent were not successful; 5.13 percent did not respond), while only 10.3 percent indicated success in reducing stereotypic responses in groups (71.8 percent were not successful; 18.0 percent did not respond to the question for groups). Zoos reported using a variety of techniques to reduce abnormal behaviors. The most common was a change in diet, both in content and in frequency. Other techniques reported included enrichment, modifying group membership, and changing housing and exhibit conditions.

Table 5: Number of institutions reporting observed changes in abnormal behaviors when animals housed in an outside exhibit location. Data from the 39 responding institutions in the Gorilla Husbandry Survey, expressed in percentages of institutions reporting an observed change.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Reporting Increase</th>
<th>Reporting Decrease</th>
<th>Reporting No change</th>
<th>No answer/Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coprophagy</td>
<td>7.7</td>
<td>35.9</td>
<td>28.2</td>
<td>28.2</td>
</tr>
<tr>
<td>Hitting head/body</td>
<td>0.0</td>
<td>0.0</td>
<td>25.6</td>
<td>74.4</td>
</tr>
<tr>
<td>Over-groom offspring</td>
<td>5.1</td>
<td>2.6</td>
<td>23.1</td>
<td>69.2</td>
</tr>
<tr>
<td>Over-groom others</td>
<td>0.0</td>
<td>0.0</td>
<td>25.6</td>
<td>74.4</td>
</tr>
<tr>
<td>Over-groom self</td>
<td>2.6</td>
<td>10.3</td>
<td>28.2</td>
<td>61.5</td>
</tr>
<tr>
<td>Pacing</td>
<td>0.0</td>
<td>2.6</td>
<td>25.6</td>
<td>71.8</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>2.6</td>
<td>20.5</td>
<td>25.6</td>
<td>51.3</td>
</tr>
<tr>
<td>Regurg./Reingestion</td>
<td>5.1</td>
<td>33.3</td>
<td>38.5</td>
<td>23.1</td>
</tr>
<tr>
<td>Rocking</td>
<td>0.0</td>
<td>7.7</td>
<td>30.8</td>
<td>61.5</td>
</tr>
<tr>
<td>Self-biting</td>
<td>0.0</td>
<td>2.6</td>
<td>25.6</td>
<td>71.8</td>
</tr>
<tr>
<td>Thumb/finger sucking</td>
<td>0.0</td>
<td>5.1</td>
<td>35.9</td>
<td>59.0</td>
</tr>
</tbody>
</table>

Note: Again, it should be noted that these behaviors are based on keeper recollection, not systematic behavioral observation. These behaviors may be more easily observed in an indoor environment that is more proximate to the keepers.

The survey also asked whether these behaviors had been observed in response to specific stimuli. Almost half the zoos (48.72 percent) indicated an observed correlation; the same percentage responded negatively (2.56 percent did not respond to this question). Zoos commonly
reported abnormalities in response to crowds, the presence of veterinary staff, and familiar caretakers leaving, among others.

**INTERVENTIONS**

A number of suggestions appear in the literature regarding etiology of stereotypies, coprophagy, and R/R, including boredom, stress, restricted living areas, insufficient food, substrate effects, digestibility, and food that is too rich (Bowen, 1980; Akers and Schildkraut 1985; Gould and Bres, 1986; Ruempler, 1992). Additionally, it has been suggested that gorillas may engage in coprophagy to increase the nutrient value of their food (Harcourt and Stewart, 1978; Fossey, 1983), and that R/R may develop because gorillas simply like the taste of the regurgitant (Ruempler, 1992). There are a number of reports of zoos attempting to reduce/change behaviors based on these ideas.

Several zoos have reported attempts to reduce R/R by changing diets. At the Cologne Zoo (Ruempler, 1992), a variety of processed foods were removed from the diet of six gorillas, the oldest male of which engaged in R/R through most of the day. In the place of the removed foods, browse of a variety of plant species were provided *ad libitum* several times through the day to supplement a vegetable-based diet (Ruempler, 1992 provides a list of 39 vegetables provided through the different seasons). The author rightly calls the change in the animals "astonishing," because all R/R disappeared within two days of the change of diet. Several days later, coprophagy was seen in several gorillas; it was also eliminated by adding more vegetables to the animals' diet. An additional correlate of the change of diet was a decline in aggression and an increase in play. The zoo maintained the strict vegetable/leaves diet for slightly more than a year, and then gradually introduced more foods (dog food, monkey chow, sunflower seeds, wheat, cooked meats) without seeing a resumption of the abnormal behaviors.

Gould and Bres (1986) manipulated the diet of gorillas in two ways in an attempt to modify R/R. They initially modified the digestibility of the diet by blending entire meals for four gorillas for two successive days. They found that R/R continued in the three gorillas that engaged in this behavior. The second manipulation, providing 6 species of browse 24 hours a day, resulted in a significant decline in R/R and an increase in time spent eating.

The previous two studies reduced R/R following the introduction of browse to the gorillas. The other manipulation (digestibility) reported by Gould and Bres (1986) was not successful. Other forms of intervention have also proven to be less successful than found with the introduction of browse. For example, Akers and Schildkraut (1985) also manipulated diet and feeding schedules in an attempt to reduce R/R in two gorillas. The removal of greens, meat, and rice cake (mixture of raisins, rice, corn syrup, cereal, and water) resulted in an increase in late afternoon R/R in the male, although as a change to three equal meals through the day occurred, there was an ultimate decline in this behavior in the male. There was no apparent change in the female gorilla with either of the manipulations. These authors provide an interesting discussion of the R/R and coprophagy literature and suggest that these behaviors are common in captivity because gorillas are natural foragers that use R/R and coprophagy to cope with their relative inability to forage in captivity. These authors note that captive gorillas are commonly in situations in which feeding can consume less than 30 minutes per day (compared
with 4 to 5 hours per day for wild gorillas), and in which the captive environment has less adequate space, social interactions, and environmental stimulation.

There are other possibilities for reducing R/R. At Zoo Atlanta, we have noted a fortuitous change in R/R following a minor modification designed to increase the observability of the group (Hoff and Maple, in press). This group had developed a habit of sitting on a concrete pad at the entrance to the holding area, out of the view of visitors. We sectioned off part of the concrete pad with electric fencing in a successful attempt to move the animals to a visible location. The fortuitous change in R/R was found in the silverback male, "Ozoum." He regurgitated onto concrete and then reingested by scooping the regurgitant up with his hand. When he was restricted from the concrete pad, his R/R stopped. It began again when he was moved to another exhibit and was able to stay on the concrete pad. So, "Ozoum's" R/R is apparently substrate-specific. It is possible that R/R in other gorillas is similarly subject to environmental regulation and may be managed by modifying the exhibit and/or caretaking patterns.

**RECOMMENDATIONS**

Zoos that are interested in modifying such behaviors in their gorilla collection are encouraged to study the behaviors in their gorillas in a systematic way, typically by using a pretest/posttest design. This design involves identifying behaviors of concern and recording them in a pre-manipulation situation and then again in a post-manipulation situation. An analysis of antecedent events, feeding schedules, type of food given to the animals, environmental and social stressors, substrates, and idiosyncratic patterns of behavior is an appropriate first step. Modification of the environment, along with careful measurement of the associated change in behavior, if any, will allow the zoo staff to determine whether an effective way to modify the behaviors of interest has been found.

One possibility for reducing R/R and/or coprophagy, given the successes reported by Gould and Bres (1986) and Ruempler (1992), is provisioning with a variety of browse and a reduction in processed foods. Recalling that the survey results presented in this chapter indicated a general decline in abnormal behaviors in outdoor exhibit areas, some zoos with both indoor and outdoor exhibit areas might exhibit animals that engage in R/R and/or coprophagy in the outdoor exhibits. Zoos that are planning to rebuild gorilla areas might also keep the survey data in mind. The previously discussed work of Meder (1989), comparing mother-reared and hand-reared gorillas, points out the value of making every reasonable attempt to allow mother-rearing of infant gorillas. In those instances in which an infant must be hand-reared, the least-deprived environment possible should be provided. We (Maple and Hoff, 1982) have previously argued that hand-rearing is on a continuum, from essential isolation to socialization by humans to being raised in complex peer groups. These latter forms of rearing will best position hand-reared infants to meet the behavioral challenges in their lives, in both individual and social domains.

Other interventions are subject to the innovation of the zoo staff. The type of changes that zoos have introduced in attempts to increase appropriate maternal care in captive gorillas are indicative of the possibilities. For example, Keiter and Pichette (1977) and Joines (1977) used
dolls, Joines (1977) used movies, and Mager (1981) used an infant spider monkey as a model, all of these in attempts to train gorilla females to engage in appropriate maternal-care patterns. While it is impossible to determine the effectiveness of these particular interventions because of the necessary case-study nature of the research, this type of innovation in examining and intervening in other forms of abnormality may help reduce the incidence of undesirable behaviors.
Harcourt et al. (1981) reported that wild female mountain gorillas reach menarche at 7 to 7.5 years, based on the timing of the first observed swellings. Watts (1991) has suggested that menarche is reached somewhat earlier, at 6 to 7.5 years, using age of first observed swelling and/or first complete copulation as the criteria. Although there are few reports in the literature, it appears that captive lowland gorillas may begin sexual cycling even earlier. Dixon (1981) stated that menarche occurs between the ages of 6 and 7, although no data were presented. Keiter and Pichette (1979) described labial tumescence and copulatory activity in two captive females, ages 5 to 6 and 6 to 7. In both females, estrus first occurred at age 5 1/2. Furthermore, information from husbandry questionnaires received from 29 institutions housing gorillas indicate that the age of females at the time of first estrus ranged from 5 to 11 years. Based on hormonal and behavioral indicators, as well as perianal swelling, Patterson et al. (1991) reported that the female "Koko" began sexual cycling at the age of 5 years, 9 months.

In comparison to chimpanzees, the sexual swellings of female gorillas are quite subtle. Labial tumescence appears to be more evident in adolescent females but very inconspicuous in adults (Watts, 1991). However, even among adolescents, there appears to be variability in the degree of swelling shown. In some females, it may be apparent only through close visual inspection or palpation. In a long-term study of lowland gorillas at the Los Angeles Zoo (duBois, in prep.), three females showed evidence of sexual cycling at age 5, based on copulatory and masturbatory behaviors. Sexual swelling (noticed primarily because of the bright pink coloration of the labial mucosa) was obvious to observers in only one of these females.

According to Watts (1991), the cycles of adolescent females are more variable and irregularly spaced than that of adult, nonpregnant females. Cycles also tend to be shorter for adolescent females. There is little quantitative data on the sexual cycling of captive adolescent females, but Noback's (1939) early work and unpublished accounts indicate that captive adolescent females also have more irregular cycles than adults. Further research documenting the onset and development of female estrus cycles in captivity is needed. Data from wild mountain gorillas (Harcourt et al., 1980; Watts, 1991) indicate that females go through about two years of adolescent sterility. Dixon (1981) examined data (but did not cite sources) from eight captive lowland gorillas that also indicated the existence of a period of adolescent sterility, lasting as little as four months or as long as two years. Age of first conception in these females ranged from an estimated 6 years, 9 months to 9 years, 8 months with a mean of 8 years, 7 months. (For further information, see Patton et al., this volume.)
TEMPERAMENT

In chimpanzees, it has been noted that adolescent females exhibiting their first sexual swellings are often "cranky," irritable, and difficult to manage (Keeling and Roberts, 1972). There are no reports in the literature documenting such behavioral changes in gorillas. However, Keiter and Pichette (1979) do mention that they observed two subadult females to initiate increased playful and affectionate behaviors toward human caretakers during estrus.

SEXUAL BEHAVIOR

There is little published information specifically regarding sexual behavior in adolescent female gorillas. Fossey (1983) described the behavior of the female mountain gorilla, Pantsy, who began cycling at the end of her seventh year. At that time, she began to frequently solicit 11 year old Icarus, who responded by mounting her if the silverback, Beethoven, was not nearby. Fossey describes Pantsy as "coquettish when flaunting her newly acquired sexual prowess." Both Nadler (1986) and Watts (1990) have described the extensive sociosexual behavior of wild mountain gorillas and have reported that all age/sex combinations are observed. However, according to Watts (1991), adolescent females copulate mostly with immature males, who usually can copulate successfully only when not in the vicinity of the dominant silverback. In Watt's study, males initiated over 80 percent of the copulations with adolescent females. As females mature, they tend to initiate more copulations (approximately 60 percent).

Reports from both the wild and captivity describe the playful nature of sexual activities in immature gorillas ranging in age from infancy through adolescence. Nadler reported that all copulatory behavior in wild immature animals occurred within the context of play, whereas Watts reported that approximately 70 percent of mounts occurred during play sessions. In Keiter and Pichette's study (1979), the sexual behavior of a captive group consisting of four subadult gorillas (two males, ages 5 to 6 and 7 to 8, and two females age 5 to 6 and 6 to 7) was described. During the adolescent females' estrus periods, they initiated an increased amount of play behavior toward the males, including twirling from the end of ropes in close proximity to the males, play-chasing, and slow wrestling and gentle caressing. Following wrestling and caressing behavior, the females often presented. According to Keiter and Pichette, during estrus the females were more vigorous toward the males, initiating 80 percent of the courtship play and engaging in activities that attracted the males' attention.

In three adolescent females studied at the Los Angeles Zoo, a great deal of variety was seen in the development of sexual behavior. The following examples (unpublished data) serve to illustrate this variability. Hormonal profiles conducted on the female, "Cleo," indicated that she was ovulating and menstruating at the age of 5. Even prior to this, "Cleo" had been engaging in frequent bouts of sexual play, including mutual genital exploration and incomplete copulation with two adolescent males. During adolescence, these behaviors continued to occur at any point throughout her cycles. However, at age 5, "Cleo" was first observed to sexually solicit her mother, "Sandy," on a monthly basis. During these periods, "Cleo" frequently followed and presented to "Sandy." "Sandy" responded by inspecting "Cleo's" genitals and by mounting her dorso-ventrally or ventro-ventrally. By the age of 6, homosexual behavior involving "Cleo" and her mother appeared to decline and "Cleo" was first observed to masturbate as well as increase
sexual interaction with the young males during her estrus periods.

A few months later, she was first observed to sexually solicit an adult male. Much of this behavior was described as "silly" or "playful" by observers and involved attention-getting antics such as clapping, handstands, standing bipedally and waving arms, and throwing twigs at the silverback. Later, she performed a myriad set of behaviors called "play presents," as well as sexual solicitation described as "pronking" (bouncing up and down on all fours). These behaviors were seen with greatest frequency during estrus. At the age of 6 1/2, "Cleo" was first observed to mount adult females who were in estrus, and she began to show extreme interest in the sexual activities of other adult gorillas. "Cleo's" first complete copulation with an adult male occurred at the age of 7 1/2. Her first parturition occurred at the age of 8 1/2.

The female "Rapunzel" was introduced, at the age of 4, to a gorilla group at the Los Angeles Zoo. During the initial months of her introduction, she socialized little with other gorillas, although she was occasionally seen to masturbate. When "Rapunzel" was almost 6 years of age (21 months after introduction), she was first seen to solicit and copulate with an adult male. During her adolescence, she demonstrated none of the playful sexual behaviors exhibited by "Cleo," possibly because she had not yet formed strong affiliative bonds with any other group members. During estrus periods, she engaged in frequent episodes of masturbation, a behavior that has continued into adulthood.

Unlike "Cleo" and "Rapunzel," the female "Angel" was mother-reared and remained in her natal group for the first 7 years. Beginning at the early age of 5 months, she began engaging in copulatory behavior with her 8 1/2-month-old half-brother. This behavior frequently occurred in playful contexts throughout the seven years these two animals were together. These behaviors occurred at any time during the month, making it difficult to establish the actual onset of sexual cycling in this female. Furthermore, she was never seen to sexually solicit the silverback male. Rather, she engaged in playful sexual behavior almost exclusively with her young half-brother. At the age of 7 years, she was moved to a different social group and almost immediately solicited and copulated with the adult silverback.

In summary, it appears that individual differences as well as differences in social history and context may affect the expression of a wide variety of sexual behaviors during female adolescence. More research is needed to elucidate general patterns, if indeed they exist.

**MALES**

**PHYSICAL CHANGES**

Watts (1991) has slightly modified the age/sex classification of wild mountain gorillas given by Harcourt et al. (1980). Males ages 8 to 12 years are considered blackbacks; those 12 to 15 are young silverbacks, indicating that they are silvering but not yet fully mature until about 15 years.
According to Dixon (1981), the exact age at which puberty begins in male gorillas has not been determined. Adolescence is not a discrete event but a variable period of life when a number of physical, hormonal, and behavioral changes occur. Male gorillas grow in size and stature, the reproductive system matures, and there are secondary sexual changes, such as the gradual development of the silver saddle of hair on the back. Presumably there is an increase in testosterone secretion during puberty, but these levels have not been measured in gorillas.

Wild mountain gorillas show complete copulations by age 9 to 10 years. Keiter and Pichette reported that the age of first intromission in captive gorillas ranged from 5 to 10 years, based on their study and on survey results. Captive lowland gorillas as young as eight years are known to have sired infants (Beck, 1982).

BEHAVIORAL CHANGES

There is little quantitative data regarding behavioral changes in adolescent male gorillas. Nadler (1986) has described the high level of playful copulatory behavior occurring in immature mountain gorillas ranging in age from infancy through 10 years. According to Watts (1990), members of all age/sex classes in wild mountain gorillas initiate mounts, but blackbacks and young silverbacks initiate the most, usually with juveniles and subadults. Once animals reach blackback status, they no longer are mounted by others. The dominant silverback will tolerate copulations between his sons and daughters (or granddaughters), but not between his sons and females who are his own mates. Presumably, subordinate males who attempt to sneak copulations with the silverback's mates risk aggressive retaliation.

There appear to be no captive studies regarding compatibility between maturing males within social groups, although this is an issue of concern in gorilla husbandry. It does appear that captive subadult males may show increased amounts of aggressive behavior, sometimes necessitating their removal from the group. Aggression first becomes evident in an increased level of aggressive play.

At the Los Angeles Zoo, the young male Caesar began showing increased aggressive behavior toward other group members at about age 10. Most of this behavior was directed toward animals other than the dominant silverback, a male unrelated to Caesar. By the age of 12, Caesar directed so much aggression toward the silverback's two-year-old son that zoo management decided to remove Caesar from the group. Surprisingly, the silverback rarely intervened during these aggressive encounters.

We are currently observing two other males, both age 7, who remain in their natal groups. Both are initiating an increased number of play interactions that have aggressive and antagonistic overtones—often described as "teasing" behavior. This behavior includes bluff-charges, slapping, and hitting with branches, and it is directed at all group members, including silverbacks. These young males have also been observed to interfere with copulations between adults. Thus far, the behavior has been tolerated without serious retaliation.
ESTROUS CYCLE AND COPULATION

L. Patton, J. Ogden, N. Czekala-Gruber

ESTROUS CYCLE LENGTH: BEHAVIOR AND PHYSIOLOGICAL CHANGES

CYCLE LENGTH

Even though the gorilla is a menstruating species, field researchers viewing the animals at a distance cannot detect menstruation. Similarly, detecting menstruation in captivity is often difficult. While menstruation itself may be difficult to observe, it is generally possible to observe anatomical and behavioral changes during the reproductive cycle. These sexual changes are described as estrous cycles. In the field, perineal tumescence (genital swelling) indicates estrus in nulliparous females. Genital swelling generally is not visible in parous females. Therefore, occurrences of sexual behavior and copulation typically are used to judge cycles in parous females (Harcourt et al., 1980). Based on behavioral cues, field workers report that estrus lasts 1 to 3 days, with cycle lengths of approximately 27 days (Harcourt et al., 1981). Fossey (1982) reports a 26-day cycle for nulliparous females.

Physiological measures, including temporal patterns of steroid and protein hormones in blood and urine, paint a similar picture, and provide support for the use of behavioral correlates of hormonal changes (Nadler et al., 1979; Mitchell et al., 1982; Nadler et al., 1983; Czekala et al., 1987; Czekala et al., 1988). Hormonal analysis reveals cycle lengths ranging from 21 to 49 days, with an average length of 33 days (serum: Nadler et al., 1983), 32 ± 1 day (urine: Mitchell et al., 1982), and 30 ± 1.5 days (urine: Czekala et al., 1987).

The majority of survey respondents (61.5 percent) do record female cycling on a regular basis. Seventy-four percent use behavior as their method of determining estrus, 33 percent use urinary assays, and 48.7 percent use observation of menses (numbers add to more than 100 due to use of multiple methods).

HORMONAL PATTERNS

Gorilla hormonal patterns during the menstrual cycle are similar to those in humans (Gould, 1982; Nadler and Collins, 1984). The menstrual cycle begins with the shedding of the endometrial lining of the uterus. This event may be monitored in captive gorillas' urine using "Hemastix" (Upjohn Company), which detects blood in the urine (Reichard et al., 1990). Following menstruation, follicular growth begins (follicular phase). During the early follicular phase (the first day of menstruation to the onset of the sustained preovulatory estrogen excursion), estrogen levels remain constant and low (14.9 ± 4.9 days). These levels are significantly lower than estrogen levels during the late follicular phase (the beginning of the preovulatory estrogen excursion to the estrogen peak) (2.1 ± 1.0 days) (Czekala et al., 1987).
As the follicles grow, estrogen concentrations increase to a sharp peak near the midpoint of the cycle, followed by a surge of lutenizing hormone (LH) from the pituitary gland (Nadler et al., 1979). This increase in LH stimulates ovulation and may be monitored in gorillas' urine using a commercially available test, such as Ovuquik (Quidel, San Diego, CA). The period of positive response to this test may occur subsequent to masturbatory behavior (Gould and Faulkner, 1981). During this time, estrous behavior is exhibited.

Following ovulation, the ruptured follicle is transformed to a corpus luteum. This corpus luteum produces progesterone. Following the midcycle peak in LH, gorillas exhibit a pronounced elevation in progesterone (luteal phase) (Nadler et al., 1979, Nadler and Collins, 1984). Following the luteal phase, menses then repeats.

Complete menstrual cycles and their components in the gorilla may be defined by the evaluation of total urinary immunoreactive estrogens (follicular phase: 19.5 ± 1.0 days) and the progesterone metabolite pregnanediol-3-glucuronide (luteal phase: 12.3 ± 0.3 days) (Mitchell et al., 1982). These values are comparable to those of Czekala, Mitchell, and Lasley (1987), who, by measuring urinary total estrogens, found the follicular phase to average 17.1 ± 2.0 days and the luteal phase to average 13 ± 1.1 days. Nadler and coworkers (1986) report the luteal phase of the cycle to average 12.2 days.

Labial tumescence (LT) in the gorilla is unobtrusive and limited to the external perineal labia. Based on cyclicity in LT, the gorilla menstrual cycles average 31 to 32 days. The swelling may be monitored by measuring the length of the vulval cleft and eversion of the vulval lining. This swelling remains at maximal size for one to four days and may only be monitored in cooperative animals (Nadler, 1975). Measurements of tumescence range from one to four centimeters (Noback, 1939, as reported by Nadler, 1975); some females are more readily detectable than others (Nadler, 1975, Reichard et al., 1990).

Cyclic variations in labial tumescence correlate positively with plasma estrogen concentrations and with female solicitation and copulation. Maximal LT occurs in association with the midcycle peak in 17β-estradiol (Nadler et al., 1979, 1983). The LH peak, a feature considered to be an indicator of ovulation in women (Nadler et al., 1979), occurs during the one to four day period of maximum tumescence. Nadler and colleagues (1979) report the peak to occur on the day following the first day of maximal tumescence. Slightly greater variations in the timing of the LH peak have been reported, but this peak always occurs during the period of maximal labial swelling (Graham, 1982). The first day of detumescence occurs zero to three days after the LH peak and at the same time as the luteal-phase increase in progesterone. At this time, there is a decline in 17β-estradiol (Nadler et al., 1979).

**COPULATORY BEHAVIOR**

**COPULATION AND ESTRUS**

Gorillas exhibit no obvious breeding season (Schaller, 1963; Cousins 1976; Fossey, 1979; Harcourt et al., 1980). As is typical for nonmonogamous mating societies, the majority of
gorilla copulations are restricted to a brief period of one to four days during the periovulatory phase of the cycle (Nadler, 1976; Harcourt and Stewart, 1978; Harcourt et al., 1981, Mitchell et al., 1985). During this period, maximal or close to maximal tumescence is exhibited and elevated levels of estrogen are present (Nadler, 1975, 1976, 1979, 1981). Copulation occurs for an average of two and three days for adults and adolescents respectively (Harcourt et al., 1980, 1981).

**Initiation of Copulation**

Free-ranging males rarely try to copulate with females that are not proceptive (Watts, 1990). Adult females are primarily active in initiating copulation (Harcourt and Stewart, 1978; Harcourt et al., 1981; Fossey, 1982; Nadler, 1976, 1987). This is seconded by survey respondents. Of the 26 institutions who responded to this question, 88.5 percent felt that females initiated most frequently. A threshold level of estrogen may be necessary to induce proceptive behavior, as this behavior does not occur during the early follicular phase when estrogens are low (Mitchell et al., 1985).

Cycling females appear to control their proximity to the troop leader. When not in estrus, females are typically at least five meters away from males (Harcourt, 1979), while during estrus, females maintain close proximity to the male. Estrous females often follow the silverback in a characteristically slow and hesitant soliciting approach, stare at him often throughout these days, and present for copulation frequently (Harcourt, 1979; Harcourt et al., 1981; Fossey, 1982).

The female's final approach to the male is often reported to be preceded by a signal from the male. He may open his arms "as if preparing to receive the female" (Harcourt et al., 1981), or he may perform part or all of a chest-beat display. Additionally, it has been suggested that the male's chest-beating and charge serve to elicit a solicitation response in the female. In a series of experiments, Nadler (1981, 1982,) concluded that male display behaviors serve as a cue to females. Nadler (1987) suggests that, following the final stiff-legged, tight lipped stance at the termination of the male's charge, the female approaches and backs into the male (Nadler, 1987). Females have also been reported to use a variety of methods to present for copulation, such as quadrupedal "bouncing" or "pronking" (see duBois, this volume).

**Copulation**

The most common copulatory position between adult gorillas is dorso-ventral (Harcourt et al., 1980; Fossey, 1982). Mating in the wild happens mostly during travel-feed time and rarely during rest. Copulatory rates for females range from 0.16 to 1.22 copulations per hour. When only one female is in estrus, copulatory rates for males are close to those of females (Harcourt et al., 1980, Watts, 1990). When complete overlap of cycling females occurs in the wild, a rare situation, the male of the group copulates with each of these females (Fossey, 1982), resulting in significantly higher copulation rates for the male. Females who share more than one proceptive day with other females have a higher percentage of refused solicits on shared days (Watts, 1990).

Copulations, timed as the duration of the copulatory position, range from 15 seconds to 20 minutes, with an average of 96 seconds (Harcourt et al., 1980). During mating, the male either sits upright or leans forward bipedally and holds the female around her waist. The female either
squats on the male's lap or bends forward on her elbows with her rump made accessible. She sometimes has her hands on the ground and at other times holds the male's hand or hands (Harcourt et al., 1981; Fossey, 1982). Mounts may be followed by 30 to 45 seconds of adjustment followed by thrusting. Males execute rapid pelvic thrusts during copulation, while females perform deep, slow body thrusts (Nadler, 1976; Harcourt et al., 1980). Females often compress lips, while males display a pursed lip expression (Harcourt et al., 1981; Fossey, 1982). Intromission is generally difficult to detect, and in captivity it is often assumed if the copulatory position is correct and thrusting occurred.

During copulatory bouts, vocalization may occur for 20 to 40 seconds (Harcourt et al., 1981, Fossey, 1982). Normal female copulatory vocalizations are rapid pulsating whimpers, and the male gives long grumbles or pulsating pants. Soft-sounding hoots of short duration become more prolonged as copulation progresses (Harcourt et al., 1981; Fossey, 1982). Sounds during this time can extend into howllike noises, which may attract attention of other group members (Fossey, 1982). The mount is generally broken by the female, who is first to move away at separation (Harcourt et al., 1980; Fossey, 1982).

**Copulation in Wild Males**

Males first attempt copulation at about the age of eight. They do not immediately show adultlike, completed copulation, and it is not known when they become fertile, although Watts (1991) estimates that they are probably fertile before 15 years of age. Gorillas are polygamous; some males have harems of ten, others two, and some none for a number of years (Schaller, 1963). Gorillas have been thought to have a one-male harem group structure (Watts, 1990). However, one-third of mountain gorilla groups in the Virunga region have more than one silverback. Multi-male groups are more common than previously thought and six percent of all animals living alone are males (Harcourt and Fossey, 1981; Robbins, in press).

In multi-male groups, it is not uncommon for there to be one primary breeding male. Harcourt and coworkers (1981) reported that only the dominant male mated with the adult females of the group. Subordinate males were never seen to mate with potentially parous females, but were observed to mate with adolescent and pregnant females. Watts (1990) did observe dominant males allowing copulations between the male's known or putative daughters (even parous) and subordinate males. However, dominant males did not allow such matings to occur with immigrant females, or with females that had been previous mates. Subordinate males are known to "sneak" copulations with willing females when far enough from the dominant male so "that he cannot see them or perhaps hear any copulatory vocalizations." Groups composed solely of bachelor males have been reported in the wild (Stewart and Harcourt, 1987); in such groups, homosexual copulatory behavior has been regularly observed.

**Copulation in Captive Males**

In general, the pattern of copulatory activity in captivity is similar to that seen in the wild, with both captive and wild gorillas confining breeding to estrous periods (Harcourt et al., 1981; Maple and Hoff, 1982). Sneak copulations by an adolescent male have been observed by the Philadelphia Zoo. These copulations occurred in both indoor and outdoor enclosures; both areas incorporated visual barriers and complexity (Jendry, pers. comm., 1995). Survey
respondents agreed that the majority of male sexual interest was observed during the week of measured ovulation (82 percent), with only 25 percent reporting sexual interest during the week before and 10 percent the week after.

As noted above, multi-male groups are becoming recognized as common in the wild. Both multi-male heterosexual groups and all-male groups are also becoming more common in captivity, primarily through necessity, as captive managers struggle to place males in social groups. As is true with free-ranging gorillas, multi-male heterosexual groups in captivity traditionally have only one breeding male (Kerr, pers. comm.; Elrod, 1993), and all-male groups exhibit homosexual mating behavior (Porton, et al., 1992).

There have been suggestions that transferring animals into a group leads to increased copulation and conception. As an example, Reichard, et al. (1990) reports that the addition of a new male resulted in pregnancies in three females who had been exhibiting no copulatory behavior with the previous male. Similarly, Watts (1990) reports that the sexual behavior of an older male was renewed when a female immigrated into the group. Unfortunately, little systematic data on this phenomenon exist, although a study by Glick and Nash (1992) suggested that the effect may be more perceived than real, at least in captivity.

While breeding is generally confined to estrous periods, housing constraints may lead to increased mating. When access is constrained and animals are introduced to each other suddenly, inappropriately timed copulations are more likely (Nadler, 1981; 1982; 1983), and mating occurs more frequently than the species-typical pattern. Housing in these instances prevents the females from achieving spatial separation from males, and males initiate the majority of copulations (Nadler et al., 1983).

Although frequencies of mating during the above-described laboratory studies are higher than those normally seen in gorillas, there is a reduced incidence of conception (Nadler and Miller, 1982; Nadler, 1982). A speculative and perhaps interesting cause for decreased conception rates may be due to the relatively small testis of gorillas (Cousins, 1976). Silverbacks are not physiologically adapted to high copulatory rates. With testis smaller than any other great ape, gorillas have a low rate of sperm production. These small testes produce a concentration of sperm of about $50 \times 10^6$ sperm / ejaculate, compared to $255 \times 10^6$ for humans, $65 \times 10^6$ for orangutans, and $600 \times 10^6$ for chimpanzees (Short, 1979). Unnaturally frequent copulations and ejaculation before or after ovulation (i.e. nonfertile phases) could compromise males' sperm output to subfertile levels at the important time of ovulation, and hence lead to perceived infertility in males (Short, 1981). However, Watts (1990) provides data suggesting that sperm depletion resulting from shared estrous periods did not significantly affect conception rates in wild mountain gorillas.

There is a possibility that some fertility problems in zoos might be attributed to the unnatural condition of proximity between male and female gorillas, which might lead to an unnatural frequency of mating and thus sperm depletation. This may be contradicted by the consistent appearance of breeding primarily during estrus. In any case, an important consideration in promoting captive breeding of gorillas may be to provide options to the female to regulate the frequency and timing of mating (Nadler, 1984; 1989).
Harassment of Copulating Animals

Harcourt et al. (1980) and Harcourt et al. (1981) reported that male and female gorillas rarely interfere with a copulating pair involving a dominant male, although Fossey (1982) found high-ranking females sometimes interfere with copulations of silverback males and subordinate females. However, dominant males frequently stop the matings in which subordinate males are involved (Harcourt et al., 1981, Fossey, 1982). In gorilla groups with more than one sexually active male, there can be within-group competition for access to the estrous females. However, as most mating occurs during travel-feed time, a second male is rarely close enough to a copulating dominant male to have the opportunity to interfere (Watts, 1990).

SUMMARY

1. Gorilla hormonal patterns during the menstrual cycle are similar to those of humans. Cycles range from 21 to 49 days, with an average of 32 days.

2. Sexual behaviors (which have been correlated with physiological measures) and copulation are used to denote estrus in gorillas.

3. The preovulatory surge of LH may be monitored in gorillas' urine using a commercially available test kit. This surge is associated with breeding behavior. Ovulation occurs during the 1 to 4 days of maximal labial tumescence. Most copulations are restricted to this preovulatory phase of the cycle (housing constraints may lead to mating times other than estrous).

4. Estrous females solicit the majority of copulations, which most commonly occur in the dorso-ventral position and average 96 seconds (range 15 seconds to 20 minutes). Intromission may be hard to see and is often assumed if the correct position and thrusting occurred.

5. Gorillas are polygamous. In the wild, one-third of all groups consist of more than one silverback with one obvious breeding male. Multi-male groups are common in the wild. Multi-male heterosexual groups and all-male groups are becoming a necessary way to group gorillas in captivity.
GESTATION AND PARTURITION

L. Patton, J. Ogden, N. Czekala-Gruber, N. Loskutoff

AGE AT CONCEPTION

A female's first parturition in the wild occurs at the average age of 10 to 11 (Harcourt, 1980, Harcourt et al., 1981), with the earliest parturition reported at 8 years, 8 months (Fossey, 1982). In captivity, the average age of a female at first birth is about 9 years, 10 months (Cousins, 1976), with the youngest conception at 6 years (Beck and Power, 1988). Keiter and Pichette (1979), in a survey on 33 females, found a range of 6 to 16 years of age for the first parturition, with a mean of 10 years. Survey respondents reported a mean (average) age at first ovulation of 8.9 years, but with a median (middle) age of 6 years (n=17 respondents). The earliest conception reported among survey respondents was 5.5 years; 24 years was the oldest age at first conception. The average age of last conception was 17.14 years (range: 5.5 years to 35 years). The oldest female to give birth in North America was 35 years, and captive managers in our survey report an average age of last evidence of cycling at 19.3 years.

The average age of siring an infant is 10 years, 1 month (Cousins, 1976), with the youngest male siring an infant at age eight in the wild (Schaller, 1963; Fossey, 1982) and 9 in captivity (Beck and Power, 1988). Among survey respondents, the youngest male to sire an infant was 6 years, with a mean age of 11.9 years. The mean age of last siring of an infant was 23 years (range: 9 to 38 years). (It should be noted that exposure to viable partners is a likely controlling factor.)

GESTATION

Gestation ranges from 237 to 285 days, with a mean of 255 days, or 8.5 months (Cousins, 1976; Fossey, 1979, 1982; Harcourt et al., 1980, 1981). Urinary estrogen measurements may be used to monitor gestation and approximate stages of gestation (Czekala et al., 1983). Some human pregnancy test kits, which detect chorionic gonadotropin (CG), crossreact with gorilla CG and may be used to detect pregnancy (Czekala, pers. comm., 1994).

CHANGES ASSOCIATED WITH PREGNANCY AND IMPENDING PARTURITION

Pregnancy in gorillas may be hard to detect by visual observation (Schaller, 1963; Stewart, 1977; Fossey, 1979). Infrequent mating during pregnancy does occur (Nadler, 1975; Stewart, 1977; Harcourt et al., 1981). Estrous behavior in pregnant females both in the wild and in captivity has been reported to be irregularly spaced. Stewart (1977) suggests that observation of a deviation from the normal pattern of mating might be considered an indication of pregnancy.

A pregnant gorilla may exhibit one or more of the following symptoms: 1) an increase in weight, 2) breast enlargement; 3) nipple enlargement; or 4) milk expulsion. An increase in
abdomen size is frequently observed during pregnancy in gorillas. In some cases, a weight increase has been noticed about three to four months prior to birth (Lotshaw, 1971; Fisher, 1972; Mallinson et al., 1973). Nadler (1974) noted a noticeably distended abdomen two weeks prior to delivery. One gorilla regurgitated more frequently than usual two months prior to parturition (Mallinson et al., 1973). Examples of total weight gains are 6.6 kg (Nadler, 1974) and 7.5 kg (Lang 1959). Breast and nipple enlargement three to four months prior to parturition may occur. One month before delivery, mammae may enlarge even more (Frueh, 1968; Lotshaw, 1971; Mallinson et al., 1973). Milk expulsion from the breast has been reported at both 10 and 3 weeks prior to parturition (Lang, 1959; Mallinson et al., 1973). In both cases, the female licked her fingers after pressing milk from her breasts.

Observations of pregnant females have focused on changes in the mother's temperament and behavior, which may be apparent two to three months into pregnancy. These animals may become less active, quieter, and withdrawn and may seek seclusion, as evidenced by greater social spacing from their group members (Carpanzano and Ogden, unpublished data). Decreased intolerance of other troop members may also occur during pregnancy (Rumbaugh, 1967; Lotshaw, 1971). An "attitude change" was attributed to a female gorilla that gave birth without any other sign of pregnancy (Frueh, 1968). Females are reported to become unusually aloof during pregnancy (Stewart, 1977). One female became quiet and seemed more contented. She did not climb and assumed unusual positions such as leaning her back against a wall with her feet sticking straight out (Hardin et al., 1969). Unusual postures observed in pregnant females could ease the strain of pregnancy on the lower back or possibly help to decrease fluid accumulations in lower extremities (Shively and Mitchell, 1986).

SIGNS OF IMPENDING PARTURITION

Many of the females observed by Stewart (1977) and Fossey (1982) were seen mounting dominant or subdominant adult males of their group as well as other females prior to parturition. One female was noted to form a close relationship with an older nursing mother ten days prior to parturition. Three females increased the distance between themselves and the troop prior to parturition (Fossey, 1979). Alternatively, Stewart (1984) found females to desire closeness to the troop prior to parturition. Fossey (1979) observed females who seemed nervous and excitable and fed little shortly before parturition.

Signs of impending birth such as restlessness and unusual posture have been noted in gorillas as early as a few days prior to parturition (Mallinson et al., 1983). Animals may express milk at this time or may exhibit frequent urination and/or defecation (Hardin et al., 1969; Lotshaw, 1971). Only a few responding institutions reported that they regularly conduct birth watches (29.6 percent of 27 respondents).

PARTURITION

Labor is often undetected (Lang, 1959; Carmichael et al., 1962; Lotshaw, 1971; Nadler, 1975; Stewart, 1977). Detectable labor ranges from 20 minutes to 2.5 hours (Rumbaugh, 1967; Fisher, 1972; Nadler, 1974; Nadler, 1975; Stewart, 1977, 1984), although an unusual
occipitoposterior birth was preceded by a six-hour labor period (Mallinson et al., 1973), and the Columbus Zoo witnessed a seven-hour labor (Jendry, 1995, personal communication). Fossey (1979) reports births to occur at night in night nests; whereas Stewart (1977, 1984) finds most wild births occur during the day (Stewart, 1977, 1984), and some reports indicate that most captive births occur during the day (Aspinall, 1980; Maple and Hoff, 1982).

According to survey results, many institutions allow staff members to be present during parturition (64 percent) or immediately thereafter (80.1 percent). Some institutions, however, are conducting remote viewing via video and believe that this has a positive effect on the outcome of parturition and rearing, such as the San Diego Zoo. Seventy-seven percent (18 of 22 respondents) report that they leave females outside when labor is observed. Normally a single young is born, but twin births do occur rarely. The weight of a newborn is about 2 kg (Harcourt, 1980, Harcourt et al., 1981).

Immediate signs of imminent birth have been blood on the cage floor or at the females' vulva (Fisher, 1972; Nadler, 1974). Females in labor are restless, agitated, and change positions frequently (Fisher, 1972; Nadler, 1974). Muscle tension indicative of contractions has been noted (Nadler, 1974), and as contractions became severe, they may be timed at two minute intervals (Fisher, 1972). Aberrant posturing, such as head stands and the drawing of legs into a flexed position (Fisher, 1972), or lying prone with knees parallel to the body and head buried in open palms (Rumbaugh, 1967) have been noticed during labor.

As the allantoic sac emerges, the female may touch and pull at it until it breaks (Nadler, 1974). At this point, the female may place fingers to her vagina and eat shreds of the sac tissue and lick fluids from her fingers (Fisher, 1972; Nadler, 1974). Posture during birth may vary. Mothers have been reported to either squat as if to urinate (Lotshaw, 1971; Nadler, 1975) or to crouch on knees and elbows (Fisher, 1972; Nadler, 1974; Aspinall, 1980). When the infant's head emerges, the mother may reach for the baby's head to either pull the infant from her body or to catch the baby (Lotshaw, 1971; Fisher, 1972; Nadler, 1975; Aspinall, 1980). In time, the placenta is delivered (Nadler, 1971; Fisher, 1972; Nadler, 1975; Aspinall, 1980). When the placenta is delivered (Nadler, 1974; 1975), attached to infant by the umbilical cord. This cord may (Fisher, 1972) or may not (Fisher, 1972; Nadler, 1975; Aspinall, 1980) be severed by the mother. All or part of the placenta may be consumed as the mother cleans the infant (Fisher, 1972; Mallinson et al., 1973).

Mothers differ in the time in which they establish ventro-ventral contact with their infants. Some may hold the infant to their breast immediately and some may ignore the infant while consuming birth debris (Nadler, 1974; Mager, 1981, Maple and Hoff, 1982; Stewart, 1984). See the birth management section for further detail.

**REACTION OF OTHERS TO NEWBORNS**

In captivity, in the past, gorilla females were generally isolated during birth. Recently, however, this has changed, and most groups are maintained intact during parturition. In fact, this has been found to be associated with increased maternal care. The vast majority of institutions responding to the survey report that they keep the group intact during and following parturition, separating the female neither from the male (82.7 percent of 29 respondents) or from other group
members (93 percent of 28 respondents).

In the natural setting, the group members showing the most interest in newly born infants are juveniles, young female adults, and silverbacks, in that order. With the exception of other siblings, other gorillas did not approach closer than ten feet (Fossey, 1979). Stewart (1984) found females to remain in close proximity to the troop during birth. Animals approached the new pair but did not attempt contact. Older offspring of the new mother spent the most time very close to the mother.

RESUMPTION OF ESTROUS SWELLING


INTERBIRTH INTERVAL

Out of 24 infants born in the wild, only one had a sibling under five years of age (Fossey, 1979). Harcourt and coworkers (1980) report the medium interval between surviving births to be four years. If an offspring dies, the birth interval is about one year (Fossey, 1979, 1982; Harcourt, 1980, 1981).

A female's reproductive life averages 25 years, during which she may produce two to five offspring (Harcourt, 1980). Fossey (1983) and Watts (1989) report the reproductive rate to be about 0.3 infants per reproductive year in the wild; in captivity the number of infants per reproductive year is 0.11 to 0.15 (Beck and Powers, 1988).

PHYSIOLOGICAL CAUSES OF INFERTILITY AND MANAGEMENT TOOLS

HORMONAL AND DIAGNOSTIC TESTS

Gorillas traditionally exhibit lower reproductive success in captivity than in the wild (Czekala et al., 1988), with a reproductive rate of 0.3 infants per reproductive year in the wild (Fossey, 1983; Watts, 1989) versus 0.11 to 0.15 in captivity (Beck and Powers, 1988). Beck and Powers (1988) demonstrated that the absence of sexual behavior is only partially responsible for reproductive failure, and suggest the use of diagnostic techniques on reproductively unsuccessful adult gorillas. Such diagnostic procedures for female gorillas might include: urine examinations for cyclical changes in hormonal metabolites (Mitchell et al., 1982), laproscopic ovarian exams, and exams for presence of fallopian tubes (Wildt et al., 1982). This list of diagnostic techniques is clearly incomplete; readers may referred to the Gorilla SSP Management Group's Reproductive Advisory Group or to AZA Advisory Groups, such as the Contraceptive Advisory Group.
Through comparison of parameters between fertile and nonfertile females, Czekala and her colleagues (1988; 1991) have suggested that subfertility in gorillas may be related to attenuated luteal function (Mitchell et al., 1982). An insufficient luteal phase in humans has been associated with a variety of stressors (Ellison, 1988). Translating this finding to the captive environment of gorillas, this suggests that this condition may be due to insufficient diet, general but unrecognized health problems, or environments that are in some way inappropriate. This may be alleviated with hormone replacement; in one case exogenous progesterone appeared to aid in the maintenance of pregnancy in a subfertile female at the Toledo Zoo (Reichard et al., 1990).

For males, such evaluation might include semen evaluation (Platz, 1980; Bader, 1983; Boer, 1983; Gould, 1983). Semen may be obtained from animals that spontaneously masturbate, with the males trained to provide a semen specimen on demand into an artificial vagina. However, this is often too problematic, and electroejaculation is used instead. Semen samples collected by rectal probe electrostimulation, or electroejaculation, from anesthetized male gorillas have generally been of poor quality (Raphael et al., 1989), perhaps owing to the fact that the ejaculates were collected from males of questionable fertility after long periods of reproductive inactivity. Yet, there has been more than one case of a male diagnosed as infertile on the basis of electroejaculation that has gone on to sire one or more infants; therefore, semen quality may not be a good predictor of fertility.

When electroejaculation is attempted, ketamine hydrochloride (IM intramuscularly given) is the anesthesia most often given (Wildt, 1986). Atropine sulfate is not recommended, as it has been reported to block seminal emission in several nonhuman primate species (Roussel and Austin, 1968; Warner et al., 1974; Gould et al., 1978). Semen may then be evaluated for parameters such as volume, sperm motility, progressive motility, sperm concentration, and sperm morphology (Bader, 1983; Platz, 1987). Based on a sample of 12 captive gorillas, Wildt (1986) determined sperm parameters including: a mean ejaculate volume of 1.0 ml, with an average sperm count per ml of 191 x 10^6, and sperm motility of 0 to 80 percent, with the average number of abnormal sperm ranging from 75 to 98 percent. The characteristics of natural ejaculates collected regularly, i.e. weekly, from males trained to respond to manual stimulation have been found to contain high concentrations of motile (e.g. less than or equal to 80 percent) and structurally normal (e.g. less than or equal to 60 percent) spermatozoa (Brown and Loskutoff, unpublished data).

**DISEASE**

There are physiological problems, such as disease or nutrition, that may be related to fertility. Refer to the health section of this manual or to the reproduction advisory group.

**ASSISTED REPRODUCTION**

Artificial insemination has been successfully performed in gorillas using fresh spermatozoa (Tribe et al., 1989) and cryopreserved/thawed spermatozoa (Douglass and Gould, 1981). Oocyte retrieval has been successfully performed in gorillas by laparoscopy (Huntress et
al., 1989; Loskutoff et al., 1989) and transvaginal, ultrasound-guided follicular aspiration (Dresser et al., 1996) after ovarian stimulation with exogenous gonadotropins to produce multiple follicles. Using a protocol developed for in-vitro fertilization in humans, gorilla embryos have been produced in vitro (Loskutoff et al., 1991; Dresser et al., 1996) and offspring have resulted from the transfer of in-vitro-derived gorilla embryos (Dresser et al., 1996).

**SUMMARY**

1. A gorilla's first conception occurs within a range of 5 years, 6 months to 35 years of age. The average first birth is at 10 years and the average last conception occurs at 17 years, 2 months of age. In males, the average age to sire is 11 years, 11 months. The youngest male to sire an infant is 6 years and the mean age for siring a last infant is 23 years (range 9 to 38 years).

2. The average gorilla gestation is 8.5 months.

3. Pregnancy may be hard to detect but may be verified using commercially available human pregnancy tests.

4. Restlessness and unusual posture have been noted prior to parturition.

5. Average time from birth to next conception is 2 years, 9 months (interbirth interval: 4 years). If an infant dies, the birth interval is 1 year.

6. Physiological manifestations may cause infertility, and several diagnostic techniques may be used to assess the problems.

7. When electroejaculation is attempted, ketamine hydrochloride is recommended as the anaesthetic, because atropine sulphate may block seminal emission.

8. Human reproductive assisted technologies have been successfully applied to gorillas.
It is widely accepted that of chimpanzees, orangutans, and gorillas, the gorilla continues to be the least successful at reproducing in captivity (Maple and Hoff, 1982). Breeding has been relatively infrequent in the past. When it did occur, maternal care is often inadequate or even abusive. In fact, up until the last decade or so, most gorillas were removed at birth and hand-raised in nurseries because of observed or anticipated maternal incompetence. In 1974, Nadler reported that 80 percent of captive-born gorillas were removed for hand-rearing within the first week of life. It is not surprising, therefore, that there are relatively few studies that document detailed mother-infant interactions and early social development in captive gorillas. The most notable work from the wild is Fossey's (1979) description of development during the first 36 months of life in mountain gorillas. Hoff et al. (1981, 1983) were the first to present quantitative data on the development of captive infants living in a naturalistic group.

While the literature on gorilla social and sexual development in captivity is not extensive, there is ample evidence from studies in other primates—especially chimpanzees and macaques—to indicate that rearing conditions and early experience have profound effects on the later expressions of many behaviors. Animals raised in socially deprived or restricted environments typically exhibit aberrant behavior patterns and often fail to breed as adults (e.g. Mason et al., 1968; Turner et al., 1969; Riesen, 1971; Nadler, 1981). Such behavioral deficits are difficult or impossible to reverse (Fritz and Fritz, 1979).

King and Mellen (1994) recently examined a large cross section of chimpanzees in North American zoos to determine the relationship between early rearing experience and later successful copulatory behavior. Several variables greatly influenced the likelihood of producing sexually competent adults, including the age at which an infant was removed from its mother and whether infants were hand-reared alone, with peers or siblings, or with at least one adult conspecific. Interestingly, no single component of rearing was responsible 100 percent of the time for either breeding success or failure, indicating the complexity of developmental processes in these animals.

Beck and Power (1988) also surveyed the North American gorilla population and concluded that many cases of reproductive failure were due to deficits in sexual behavior, which, in turn, most likely resulted from lack of early social experience with conspecifics. In particular, mother-reared female gorillas were reproductively more successful than hand-reared females. This difference was not seen in males, although it was noted that sample sizes were small.

Taken together, these studies strongly suggest that gorillas and other apes that are hand-reared with limited access to conspecifics experience moderate to severe social deprivation, and that this can have detrimental effects on the development of social and sexual behavior.

King and Thomas (1992) cite studies that demonstrate the importance of additional
experiential factors in the development of captive apes. Davenport et al. (1973) compared the cognitive skills of chimpanzees that were reared in an impoverished environment for the first two years of life with chimpanzees that had come from the wild. Even after 12 years of environmental enrichment, it was found that the deprived chimpanzees performed significantly less well than the wild-born animals. It can therefore be argued that the development of cognitive, as well as social, skills is affected by early experience, and that restricted environments can cause irreparable damage.

A vast array of social and environmental factors affect the early experience of even mother-reared apes. As King and Thomas (1992) point out, studies on both wild and captive chimpanzees living in social groups demonstrate that infant experiences vary considerably from chimpanzee to chimpanzee. For example, Hemelrijk and de Kogel (1989) described the variability in maternal behavior of chimpanzees and how the behavior of mothers greatly influenced the behavior of their offspring. One illustration involved the amount of time infants spent in social play. Infants of highly sociable mothers spent less time in play, apparently because sociable mothers interacted more with other group members and initiated fewer interactions with their own offspring than did less sociable mothers.

Primate mothers, in general, greatly regulate their infant's interactions with group companions and actively encourage or discourage independence (Hansen, 1966; Hinde and Spencer-Booth; 1967; Berman, 1984; Tomasello et al., 1990). Variability in maternal responsiveness and restrictiveness is prevalent, and a number of factors—including size and composition of the social group, maternal age and parity, prior social and maternal experience, the presence or absence of older or younger siblings, maternal dominance, maternal temperament, and infant's sex—may potentially influence a mother's behavior and the way in which her infant experiences the world. In captive gorillas, environmental complexity also appears to affect mother-infant interactions. Hoff et al. (1994) found that infants spend significantly more time in contact with their mothers and less time in object exploration and solitary play when housed in an indoor enclosure as compared to an outdoor enclosure.

In summary, there is a great deal of evidence to indicate the importance of early experience in the successful development of primates, and this undoubtedly holds true for gorillas. However, because the behavioral repertoires of primates, and particularly of apes, are so flexible, and because social and environmental conditions vary widely in both captivity and the wild, considerable variation exists in the experiences infants encounter as they grow up. A better understanding of the conditions that promote the successful development of social and reproductive behaviors is obviously vital to improving the husbandry of gorillas.

Keeping in mind that behavioral flexibility appears to be a primate trend and that research findings from gorillas are still limited, the following is a general overview of infant development and parental behavior. Information is derived from the existing literature, from observations conducted as part of a long-term study on the behavioral development of lowland gorillas at the Los Angeles Zoo (duBois, in prep.), and from the results of the gorilla husbandry survey described in this manual.

The Los Angeles Zoo (LAZ) study focused on two males, "Kelly" and "Jim," and a female, "Angel," all born in 1987. "Kelly" and "Angel" lived with their respective mothers,
"Cleo" and "Sandy" in a group that contained a silverback male and another adult female. "Jim" lived with his mother, "Evie," in a group that contained a silverback male, an adult female, and an unrelated adolescent male. An unrelated juvenile female was introduced to the group when "Jim" was 1 year old.

Results from the gorilla husbandry survey are presented when appropriate, but should be regarded somewhat cautiously. Few respondents answered questions pertaining to infant development, either because the zoos did not have infants or because the information was not available. Consequently, sample sizes are small. Responses also varied widely, suggesting that the data may reflect inaccuracy rather than true variability in gorilla behavior. It is not clear whether some respondents relied on memory or written records to answer questions.

As zoos increasingly gain experience with mother-reared gorillas living in natural social groupings, it is hoped that behavioral data will be obtained so that species-typical patterns in development can be more clearly elucidated.

MATERNAL CONTACT

Like all great apes, gorillas form strong, long-lasting relationships with their mothers that gradually decrease in intensity over the long period of maturation. In the wild, gorillas associate with their mothers almost constantly for several years, even after weaning. Proximity then declines with age (Watts and Pusey, 1993). Hoff et al. (1981) stated that the development of independence by infant primates is a complex, multifaceted phenomenon, characterized primarily by a decrease in mother-infant contact with increasing age of the infant. This developmental trend has been observed in gorillas, although the ages at which mother-infant pairs break contact and show decline in proximity appear to vary considerably.

Infant gorillas are initially held or carried in the ventro-ventral fashion. When seated, the mother typically cradles the infant against her chest or holds it in her lap. However, variations can be seen, as exemplified by the LAZ study. "Sandy," a gorilla with an extremely large girth, tended to tuck her infant down under her arm against her leg, probably because her stomach protruded so much that the infant had difficulty clinging. During the first six months of life, ventro-ventral contact substantially declines and is replaced by less intimate forms of contact, e.g., an infant sits on its mother's back (dorso-ventral contact), clings to her side, or sits in contact next to her.

Schaller (1963), the first investigator to describe mother-infant interactions in wild gorillas, reported that maternal contact was initially broken at about 3 months of age when mothers first put their infants on the ground for brief periods. At 4 to 5 months, youngsters began to crawl away from their mothers, reaching a maximum distance of about 10 feet. At 6 to 7 months of age, infants occasionally toddled behind mothers during travel, and by 8 months, they ventured as far as 20 feet away. By the age of 1 to 1 1/4 years, infants often sat by their mothers rather than on them. During rest periods, they frequently wandered throughout the group, sometimes out of the mother's sight. When an infant left the proximity of its mother, it appeared to remain aware of her location and would rush back to her at the first sign of alarm.
Fossey (1979) reported that infants broke body contact with their mothers at somewhat older ages than those observed by Schaller. Contact was continuous until approximately the fifth month. By one year, infants and mothers were in contact about 50 percent of the observation time, although when off their mothers, infants usually remained within arm's distance. By the second year, infants spent about 30 percent of the observation time in contact with their mothers and about the same amount of time within arm's reach. With increasing age, infants spent less time in contact and more time at greater distances from their mothers. By 3 years, mothers and infants were frequently 15 feet apart.

The development of the first captive-born, mother-reared lowland gorilla was briefly described by Lang (1959) at the Basel Zoo. This infant did not begin leaving its mother until it was approximately 4 to 5 months of age, similar to Fossey's observation of wild gorillas. Many years later, Kingsley (1977) studied interactions between a mother-infant pair at the Jersey Zoo and reported that contact was first broken at the early age of 6 weeks, 2 days. Hoff et al. (1981) provided quantitative developmental profiles of three captive infants (two males and one female) living with their mothers and a silverback male in an outdoor enclosure at the Yerkes Regional Primate Center. The mother-infant pairs remained in constant contact for approximately the first 2 1/2 months. At this time, contact was broken but infants stayed close to their mothers. Through the remainder of the first year, the time spent in contact gradually decreased but infants did not stray farther than about 15 feet from their mothers. At about 1 year of age, infants and mothers began moving more than 15 feet apart, and by the end of the study at 18 months, they could often be seen at opposite ends of the enclosure, a distance of 75 to 100 feet.

In the LAZ study, all three infants maintained extremely close proximity to their mothers for the first six months. There were individual differences, however, in the ages at which contact was first broken: 2 1/2 months for "Kelly," 3 1/2 months for "Jim," and 5 months for "Angel." These episodes were extremely brief and can best be described as "toddling lessons." A mother would put her infant down on the grass directly in front of her, forcing it to move toward her. Infants would rock, teeter, and fall but soon began taking quadrupedal "baby steps." At the age of 9 months, "Kelly" began to travel away from his mother at a distance greater than arm's reach but usually within 10 feet. "Angel" and "Jim" were generally within arm's distance of their mothers throughout the first year of life. During the second year, the amount of time spent in maternal contact decreased considerably. However, individual differences were again notable. At the age of 20 months, "Kelly" and "Jim" spent 25 percent of the observation time in contact with their mothers, whereas "Angel" spent approximately 40 percent of the observation time in contact with hers. Proximity to mothers also decreased in the second year, but not as dramatically as the amount of time spent in contact. Even though infants were often off their mothers, they rarely ventured farther than 20 feet away.

Survey results showed that the earliest age at which maternal contact was broken with female infants ranged from 3 weeks to 6 months, with a median age of 4.0 months (n=9). The earliest age at which female infants moved at least 15 feet from their mothers ranged from 2.3 to 30 months, with a median age of 5.0 months (n=5).

With respect to males, the age at which maternal contact was first broken ranged from 1 week to 5 months, with a median age of 3 months (n=12). Age at which male infants first moved at least 15 feet from their mothers ranged from 3 to 10 months, with a median age of 4.3 months.
The wide variability seen in the ages at which infants separate from their mothers appears to result from variability in maternal restrictiveness. Hoff et al. (1981) concluded from their observations that the development of independence in infants is an interactive process between mother and infant. At about 3 to 4 months of age, the Yerkes' infants showed signs of struggling as they moved from ventro-ventral contact to less intimate forms, often in an attempt to explore the physical environment. Mothers generally responded by restraining and retrieving their infants. Levels of maternal restraint were initially very high, but subsided by the ninth month. However, mothers continued to retrieve infants throughout the 18-month study, with levels peaking in the eighth month.

As previously mentioned, a number of variables, including sex of offspring, maternal temperament and experience, and myriad social and environmental factors, might affect a mother's restrictiveness. The LAZ gorillas may provide some helpful examples. "Kelly's" mother, "Cleo," was a very relaxed gorilla that demonstrated remarkable maternal proficiency immediately after birth. Although responsive and playful with her infant, "Cleo's" maternal style can best be described as laissez-faire. She was the least restrictive of the mothers and spent the least amount of time in close contact with her infant. "Angel's" mother, "Sandy," was a very inactive gorilla, possibly due to her older age and weight problem. She tended to sit in one spot for long periods of time and repeatedly restrained "Angel" from leaving. (Our subjective opinion was that she did not want to exert any energy getting up to retrieve her infant.) "Evie," "Jim's" mother, was by far the most nervous of the females. "Evie" and "Jim" lived in a group with an adolescent male who frequently harassed them. "Evie" was extremely wary of this male and kept "Jim" in close contact or proximity whenever he was around.

It is interesting to note that in both the Yerkes and LAZ studies, relatively more maternal contact was maintained with female infants. This is consistent with reports on macaques (Jensen et al., 1967). However Fossey's (1979) impression was that male infants spent considerably more time with their mothers during the first two years, after which they more rapidly spent time at a distance than did female infants. Sample size remains too small to come to any conclusions.

TRAVEL

There appears to be some uncertainty regarding the age at which infants can cling unsupported to the ventral surface of the mother. Schaller (1963) reported that during the first month of life, infants were so rarely without support that he could not determine at what age they were able to cling. However, by the age of 1 month, infants were observed to cling when mothers climbed in trees for brief periods. Fossey (1979) stated that within 24 hours after birth, infants were capable of clinging unsupported for at least 3 minutes. Lang (cited by Schaller, 1963) noted that the grasping reflex in one captive newborn was weaker than that of a chimpanzee or an orangutan, whereas Beck (1984) observed that the grasping reflex in a newborn gorilla was strong. In the LAZ study, the infant "Jim" was seen to cling to his mother's ventrum several hours after birth, enabling his mother to walk quadrupedally. Infants "Angel" and "Kelly" were first observed to cling two to three days later.
Survey results indicated that the age at which female infants were first observed to cling unsupported to their mothers ranged from day 1 to 5 months, with a median age of 11 days (n=9). In male infants, this age ranged from day 1 to 5 months, with a median age of 14 days (n=11).

VENTRO-VENTRAL TRAVEL

The most common form of maternal transport in the first month of life is the tripedal walk, in which the mother uses one arm to support the infant against her ventrum as she walks tripedally (Schaller, 1963; Hoff et al., 1981). According to Fossey (1979), at ages 1 to 2 months, infants are capable of clinging unsupported to the ventral surface of the mother for sustained periods. Under arduous circumstances such as tree climbing, the infant may slip into a low abdominal or inner thigh position. Fossey also noted that primiparous mothers were initially less successful than multiparous mothers at supporting their infants, and sometimes carried them inappropriately, e.g., upside down, dangling from the neck, etc. However, these observations were never observed to have serious consequences.

Vento-ventral travel gradually declines and is largely replaced by dorso-ventral travel, i.e. "back-riding." Fossey (1979) found that gorillas used the ventral travel mode about 60 percent of the time at age 4 to 6 months, 40 percent of the time at age 6 to 12 months, and only rarely after the first year. At later ages, the infant may briefly revert to ventral travel under stressful situations.

DORSO-VENTRAL TRAVEL

The shift to dorsal travel is initiated by the mother, although there appears to be substantial variation in the age at which this can occur. Fossey (1979) reported that infants between the ages of 2 to 4 months will began riding dorsally for brief periods in a sideways, sprawled position if the mother pushes them onto her back. Hoff et al. (1981) reported that dorso-ventral travel first occurred in the fifth month. In the LAZ study, "Evie" made extremely early attempts in the first month to push her infant, "Jim," onto her back. Often he was positioned incorrectly, sometimes even backwards. "Evie" typically walked in circles very slowly, reaching up to give "Jim" a shove if he slipped. By the second month, he was frequently riding correctly. "Cleo" first initiated dorsal riding when "Kelly" was 2 months old, but these episodes remained brief until the third month. "Sandy" did not initiate dorsal riding until "Angel" was almost 4 months old. Initially, "Angel" rode very high on "Sandy's" shoulders.

In general, it appears that in both wild and captive gorillas, ventro-ventral travel predominates in the first half of the infant's first year, while dorsal travel predominates in the second half. Fossey (1979) found that infant gorillas traveled dorsally 40 percent of the time between the ages of 4 to 6 months. This increased to 80 percent between the ages of 6 to 12 months. Between the ages of 12 to 36 months, infants traveled dorsally during prolonged travel routes, but otherwise followed their mothers independently or clung to their mother's rump hair.

Survey results indicated that female infants were first observed to begin riding dorsally at
ages ranging from 12 days to 8 months, with a median age of 5 months (n=8). Independent travel first occurred at ages ranging from 2 months to 24 months, with a median age of 8.5 months (n=4). In male infants, dorsal riding was first observed to occur at ages ranging from 1 day to 17 months, with a median age of 2 months (n=14). Independent travel first occurred at ages ranging from 3 months to 4.5 years, with a median age of 10 months (n=8).

OTHER FORMS OF TRAVEL

Variability in the methods of transporting infants, especially older infants, is not uncommon in both wild and captive gorillas (Fossey, 1979; Hoff et al., 1983). In the Yerkes gorillas, several idiosyncratic forms of maternal transport were used to varying degrees by different mothers (Hoff et al., 1981). These forms were also observed in the LAZ gorillas and included: 1) arm walk--the mother walked quadrupedally while the infant sat in one palm and held onto her arm; 2) crutch walk--the mother walked quadrupedally while holding her infant in her lap and used her arms as crutches; 3) drag--a mother walked tripedally while the infant was held in one hand away from the body; and 5) leg walk--the mother walked quadrupedally while the infant held onto her rear leg. Hoff et al. (1983) reported that these modes of transport decreased in type and frequency by the 18th month, at which time only ventro-ventral (with infant clinging unsupported) and dorso-ventral travel were observed.

SOLITARY PLAY/OBJECT PLAY

At ages 2 to 4 months, Fossey (1979) reported that wild gorilla infants began exploratory play activities with surrounding vegetation (grasping nearby foliage) and their mother's bodies (unbalanced crawling, sliding, patting, and hair pulling). By 4 to 6 months, infants were capable of manipulating vegetation and they began patting, clapping, and whacking at their own bodies. Between 6 to 12 months, locomotor abilities developed considerably and solitary play included tree climbing, somersaulting, exaggerated tumbling, hand-clapping, leg kicking, and arm waving. Fossey stated that during the first 18 months, solitary play served the function of allowing infants to share the proximity of older, playing animals without becoming directly involved. Solitary play decreased in the third year when social play became much more frequent.

In captive gorillas, Hoff et al. (1981) observed that solitary play first occurred during the fifth month. Such play consisted of ground slapping, often while holding grass or twigs. In the seventh month, gymnastic play was initiated on a climbing apparatus. This progressed, in the 12th month, to locomotor play consisting of slow galloping and bi-pedal walks with arm waving. Solitary play increased in frequency and complexity almost continuously throughout the study, possibly leveling off shortly before 18 months. However, contrary to Fossey's findings, social play declined rather than increased at this age.

The development of solitary/object play in the LAZ gorillas followed a pattern generally resembling that described by Fossey. By the age of 1 month, infants appeared quite aware of their surroundings and frequently touched their mother's faces and reached (unsuccessfully) for objects. Between 2 to 3 months, infants were capable of sitting fairly well unsupported and they began to grasp nearby vines and grass. "Jim" was particularly interested in objects and not only grasped and poked at vegetation but also rubbed his hands in dirt. Between 6 to 12 months,
solitary play began to include rotational/locomotor components such as twirls, somersaults, rolls, jumps, climbing, swinging, and hanging (Brown, 1988). The amount of time spent in solitary play declined at about the age of 20 months when infants began to spend significantly more time in social play.

The presence of peers almost certainly affects the amount of time infants spend in solitary play. "Jim," who had no peers, maintained much higher rates of solitary play during the first two years than did "Angel" and "Kelly," who spent considerable time playing with each other. "Jim" was extremely investigative and played with a wide variety of objects found in the exhibit, including dirt, small pieces of concrete, sticks, bird feathers, walnut shells, orange peels, and vegetation. Lacking playmates, it appeared that "Jim" had to find other, nonsocial forms of occupation. The long-term effects of this are unknown.

Interestingly, Meder (1989) found that hand-reared infants performed more solitary and object play than mother-reared infants. The higher level was especially conspicuous for hand-reared infants living in pairs, but also occurred in equally aged infants kept in groups. Meder hypothesized that the comparatively high level of solitary play in hand-reared gorillas may have been the result of a lack of social and other stimulation during early infancy. Consequently, infants turned to their own bodies and immediate environment for stimulation. These behaviors persisted even after infants were later exposed to peers.

Hoff et al. (1994) observed that two mother-reared infants at Zoo Atlanta engaged in significantly more solitary play/object exploration when housed in an outdoor enclosure as compared to an indoor holding area. When indoors, infants tended to focus more attention on cage-mates, probably because this area was relatively lacking in environmental complexity.

Survey results indicated that female infants were first observed to engage in solitary play between the ages of 1.8 and 5.0 months, with a median age of 3.0 months (n=5). Object manipulation was first observed between the ages of 0.7 and 8.0 months, with a median age of 3.0 months (n=8). Male infants were first observed to engage in solitary play between the ages of 2.5 and 5.0 months, with a median age of 4.0 months (n=9). Object manipulation was first observed between the ages of 1.5 and 6.0 months, with a median age of 3.8 months (n=10).

**NURSING**

Newborn gorillas exhibit rooting and nuzzling movements of the head as well as spastic, involuntary limb movements when searching for the nipple (Fossey, 1979; Dixon, 1981). In wild and captive infants, nursing generally commences within 24 hours of birth (Fossey, 1979; Arnold, 1979; Beck, 1984), but there is variability and nursing can occur later. Nadler (1974) observed the birth of a captive gorilla and reported that prolonged nursing did not occur until the second day. Initially, this mother responded to her infant's vocalizations by growling but subsequently learned to better adjust the infant's position for nursing. Stewart (1977) observed the birth of a wild gorilla and suggested that nursing develops out of the successful coordination of the mother's repositioning of the newborn on her ventrum in response to its reflex movements and vocalizations (often described as puppy-like whines).
In the case of the LAZ gorillas, two infants, "Kelly" and "Jim," were seen to nurse on the first day. However, the infant "Angel" was not observed to nurse until the third day, much to the consternation of zoo personnel. Because of her mother, "Sandy's," huge, protruding abdomen, it appeared physically difficult for "Angel" to reach the nipple. Over the course of the next two days, however, "Sandy" learned how to nudge "Angel" up the very long climb to the breast, and "Angel" appeared not to suffer any ill effects.

According to Fossey (1979), wild gorillas became more coordinated when seeking the nipple during the first 2 months, but suckling bouts were of short duration, seldom lasting more than 50 seconds during the first 2 weeks. By the age of 2 to 4 months, infants were able to obtain the nipple without preliminary searching and would strongly pursue their efforts if discouraged by the mother. At the age of 4 to 6 months, infants continued to vigorously suckle, but bouts were of shorter duration. Stewart (1988) obtained quantitative data on the frequency and duration of suckling in wild infants between the ages of 6 to 48 months. She found that the frequency of suckling declined with age, from a mean of 1.5 bouts per hour in the first year to about 0.5 bouts per hour at age 30 to 36 months. In contrast, the duration of suckling bouts remained relatively constant throughout lactation, averaging between 2.6 and 3.2 minutes per hour. There is little quantitative data on nursing in captive gorillas. Maple and Hoff (1982) reported that nipple contact occurred throughout their 18-month study and that frequency was highest in the first month.

Inability to nurse has not been observed in the wild, but is often cited as a reason for hand-rearing captive gorillas (Bahr, 1995). In some cases, milk production is thought to be insufficient, whereas in others, mothers do not appear to allow infants to suckle (Meder, cited in Bahr, 1995). According to Bahr, physical and psychological stress can potentially inhibit the initiation and early maintenance of lactation. Milk letdown may not occur until 48 hours postpartum. This suggests that in some cases, infants may have been prematurely removed for hand-rearing. There is some evidence that increased fluid intake may help to stimulate milk production (Bahr, 1995). Miller-Schroeder and Paterson (1989) pointed out that gorillas with engorged and overly sensitive breasts may have difficulty nursing, and this may affect their willingness to accept infants. They suggested that engorgement be relieved manually if possible.

Unlike chimpanzees, infant gorillas rarely suckle from lactating females other than their own mothers. Fossey (1979) reported only two cases where this occurred. There is a report of a captive, lactating female with a 14-month-old son that adopted and suckled a female newborn (Blersch and Schmidt, 1992). The female's son died of a cardiac defect two months later, and after a year, the adopted infant was neglected and had to be removed from the group. Similarly, a lactating female at the National Zoo adopted a cagemate's newborn (Stewart, pers. comm.).

MATERNAL REJECTION FROM THE NIPPLE

Weaning is a gradual process during which the mother-infant bond is loosened. The infant becomes less dependent on the mother not only for nutritional needs but for emotional and psychological needs as well. There is little quantitative information regarding weaning in gorillas, but studies of chimpanzees (Horvat and Kraemer, 1982) and monkeys (Collinge, 1987) indicate both inter-individual variability and the importance of maternal rejection in the weaning process.
According to Fossey (1979), nursing was nearly always initiated and terminated by the mother. Between the ages of 6 to 12 months, mothers were observed to forcibly check their infants' suckling efforts. Between the ages of 12 to 24 months, infants still attempted to suckle but were more responsive to a mother's restrictive measures. At age 24 to 36 months, infants continued to suckle but mothers sometimes rebuffed infants severely if the attempts continued for too long. Stewart (1988) found that suckling frequencies in wild gorillas declined as infants matured, with the sharpest drop-off occurring between the age of 6 and 24 months. By the age of 36 months, sucking frequency was less than 0.5 bouts/hour, a rate that appeared to be correlated with the resumption of the mother's sexual cycling. Because the median inter-birth interval in wild gorillas is 3.85 years (Sievert et al., 1991), and because suckling after the first month of pregnancy was rarely observed (Stewart, 1988), it can be inferred that most gorilla infants are weaned at about age 3. However, if females do not become pregnant, their offspring may continue to nurse. Fossey (1979) observed two juveniles without siblings that continued to regularly suckle at ages 4 and 5.

In captive gorillas, Maple and Hoff (1982) observed that weaning began at 4 months of age when mothers first refused to allow infants to nurse. The mothers typically did this by crossing an arm across the breast, blocking the infant's access to the nipple. Weaning behaviors were reported to occur at low levels throughout the 18-month study, although quantitative data were not presented.

In the LAZ gorillas, there appeared to be great variation in the age at which weaning was initiated. "Evie" was first observed to push her infant, "Jim," away from the breast when he was 8 months old. By the time he was 1 year old, "Evie" made repeated attempts to interrupt nursing. Sometimes she would stand up when "Jim" started to suckle, but he would adamantly persist, clinging to her and suckling as she walked away. By the age of 21 months, "Evie" thwarted most of "Jim's" attempts to suckle, and by the age of 24 months, he stopped nursing. "Cleo" did not appear to begin active weaning until her infant, "Kelly," was 23 months old. She restricted access to the nipple by covering her breast with her arm or by leaving when "Kelly" approached. When "Kelly" was 24 months old, "Cleo" was first observed to threaten him when he approached for nursing. Interestingly, he responded by immediately running to another adult female. By the age of 30 months, "Kelly" appeared to be weaned. "Sandy" nursed her infant, "Angel," far longer than did the other animals. "Sandy" was not seen to rebuff "Angel" until she was 3 years of age, and to the contrary, Sandy often attempted to maintain contact with her. Although suckling bouts were infrequent, "Angel" did not appear to be completely weaned until about 4.5 years of age. It therefore appears that variation exists not only in initial onset of weaning, but in the length of the weaning period.

It is not known whether diet affects weaning in captivity. Solid food is probably more readily available to captive rather than wild infants, and in some zoos, infants are also given supplemental cow's milk (as were the LAZ gorillas).

Survey results indicated that weaning was first attempted in female infants at ages ranging from 24 to 42 months, with a median age of 30 months (n=5); weaning was complete at ages ranging from 36 to 54 months, with a median age of 48 months (n=5). Weaning was first attempted in male infants at ages ranging from 11 to 36 months, with a median age of 24 months.
weaning was complete at ages ranging from 15 to 72 months, with a median age of 36 months (n=7).

**SOLID FOOD CONSUMPTION**

Wild gorillas acquire the basic adult feeding repertoire by the end of infancy (Watts and Pusey, 1993). As infants decrease the amount of time spent suckling, interest in solid food appears to rise. Fossey (1979) reported that 1- to 2-month-old wild gorillas began mouthing vegetation debris that fell onto the mother's body. At age 4 to 6 months, infants were seen to clumsily pluck at leaves and gnaw on stalks. Actual food preparation did not occur until months 12 to 24, when infants attempted to strip leaves from stalks and wad vines. By the age of 24 to 36 months, infants were considerably better at food preparation (wadding, stripping, peeling), and selectivity and competition for favored food items were seen for the first time.

In the LAZ gorillas, infants appeared to exhibit an "oral stage" at age 3 months. During this period, infants were extremely motivated to mouth and chew both food items and inedible objects. Mothers were sometimes seen to snatch objects out of their infants' mouths and toss them away. Actual food ingestion appeared to be limited to tiny scraps and pieces that fell on the mother's body as she ate. By the age of 4 months, infants began to eat small quantities of solids, including raisins, grapes, and bananas. Infants were extremely interested in whatever foods their mothers ingested, and peered intently into their faces as they ate. Although mothers were tolerant of infants eating "leftovers" and snatching small amounts of food that were dropped, they were not observed to share substantial quantities nor were they ever observed to offer food to infants, as has been reported in chimpanzees (Horvat et al., 1980). Fossey also (1979) noted that infants pulled at vines and leaves eaten by mothers, but that mothers were never seen to offer food.

Survey results indicated that solid food consumption was first observed in female infants ranging in age from 2.0 to 6.0 months, with a median age of 3.5 months (n=9). Solid food consumption was first observed in male infants ranging in age from 2.5 to 6.3 months, with a median age of 3.25 months (n=12).

**GROOMING**

In comparison to chimpanzees, social grooming among gorillas does not appear to be a prominent activity (Schaller, 1963; Maple and Hoff, 1982). Schaller rarely observed grooming between adults; most episodes involved mothers with infant and juvenile offspring. According to Fossey (1979), mothers always initiated grooming with infants, but infants almost always terminated the sessions. Mothers often held infants upside down or in awkward, uncomfortable positions during grooming, and infants protested with vigorous kicking and squirming. After about six months, mothers became more persistent in their grooming efforts and rebuffed infants if they resisted. During the second year of life, infants more readily accepted grooming from their mothers and bouts increased in length and frequency.

Infants were first observed to groom their mothers at 1 year of age and peer grooming first occurred at 14 months. Fossey did not present quantitative data, but Schaller (1963)
indicated that infants rarely groomed other animals. This pattern appears to persist past weaning, with mothers giving more grooming to juvenile offspring than they receive (Watts and Pusey, 1993). Juveniles tend to groom silverback males more than any other age-sex class; the highest values have occurred for maternal orphans grooming their fathers (Watts and Pusey, 1993).

Maple and Hoff (1982) reported that captive mothers groomed infants very little, and that social grooming was found at very low rates among all age/sex classes. We observed similar low rates of grooming in the LAZ gorillas. During the first few months, mothers carefully mouthed and inspected their infants, paying special attention to the ano-genital regions. However, an infant's body hair was rarely parted or systematically examined in the typical grooming manner performed by many primates. Infants were never observed to groom their mothers or other group members.

It may be of interest to note that one mother, "Evie," performed stereotypic hair-plucking on the head of her infant, "Jim," beginning when he was about 8 months of age. By the age of 12 months, "Evie" had rendered him almost completely bald. Hair plucking persisted throughout the weaning period and then gradually diminished. In fact, hair plucking may have been instrumental in the weaning process. Plucking was obviously painful for "Jim," and he often appeared to cease nursing when "Evie" began to pluck.

**SOLITARY GROOMING**

Schaller (1963) observed that self-grooming occurred in all age-sex classes of wild gorillas, but that infants under two years of age were never observed to groom themselves. Fossey (1979) reported that the youngest incidence of self-grooming was observed at the age of 1 year, but concurred that infants spent very little time grooming themselves. As with social grooming, solitary grooming was rarely seen in the LAZ gorillas, regardless of age/sex class.

**NEST BUILDING**

In wild gorillas, nest building behaviors appear to first emerge during episodes of solitary play with vegetation. The youngest animal seen to build a nest was an 8-month-old male that spent four minutes bending foliage stalks around him. During the first three years, infants constructed practice nests and gradually became more proficient. The youngest animal reported to consistently build and sleep in its own night nest near his mother was 34 months old. However, most immatures continued to night-nest with their mothers until the age of about 5 years (Fossey, 1979).

Bernstein (1969) observed the nest building habits of eight captive gorillas between the ages of 2.5 to 3.5 years. These animals moved branches together on the ground but did not construct recognizable nests, nor did they sleep on the branches. Bernstein also tested six juvenile gorillas and found that only three made appropriate nests, although over time most exhibited some improvement. Meder (1989) observed that both hand-reared and mother-reared infants showed nest building behavior beginning at the age of 6 months in females and 9 months in males. Nests were constructed of rope, wood wool, branches, paper, sacks, cloth, and plastic
toys. While hand-reared infants built nests, they were never observed to sleep in them until the age of 5 years, whereas mother-reared infants slept in their nests at the age of 2 years. It appears that gorillas may possess innate patterns for nest building, but that technique is improved with practice. Interestingly, it also appears that gorillas must learn by imitation how to use the nests they build (Meder, 1989).

Survey results indicated that nest building was first observed in females ranging in age from 5 to 48 months, with a median age of 23 months (n=4). Nest building was first observed in males ranging in age from 5 to 54 months, with a median age of 36 months (n=7).

SOCIAL PLAY

As with all apes, play is the single most predominant activity seen in young gorillas. In wild gorillas, Fossey (1979) reported that an infant's play activities expanded from play on the mother's body to solitary play to peer play in close proximity to the mother. Social play first occurred between the mother and infant when the infant was between 2 and 4 months old. As the infant wriggled, slid, and whacked at the mother's body, she reciprocated with gentle shoves and mock-biting. At age 4 to 6 months, play with the mother became more vigorous. Infants tackled the mother's extremities and mock-wrestled with other infants. At this time, infants first began to mildly whack at and pat other animals, usually while on the mother's body or near her side. At age 6 to 12 months, social play with other infants and juveniles increased but was not as frequent as solitary play. Because the infant still maintained close proximity to the mother, play with others was initiated only when others approached. Mothers were very restrictive and frequently curbed an infant's play activities.

During the second year of life, play with other infants and juveniles, especially siblings, continued to increase in frequency and vigor and began to outnumber solitary play sessions. Infants appeared to prefer playing with juveniles, although juveniles, themselves, preferred to play with partners slightly older than themselves. As mothers become less restrictive, infants also began to play with the silverback. Initially, this began when infants played by themselves or with peers in close proximity to the male. Silverbacks were generally very tolerant toward play and allowed themselves to be kicked, hit, and tumbled against. When a silverback left the resting area to feed, his day-nest often became a favorite play site for infants and juveniles. Infants were occasionally seen to play with other adult females during rest periods, but after the second year, this rarely occurred.

During the third year, infants initiated play more often and with a wider range of individuals. Play between infants and older juveniles and adolescents (approximately ages 3 to 6 years) also occurred, but Fossey described these interactions as more complex, involving not only play but components of maternal behavior, grooming, transport, and copulatory behavior.

Watts and Pusey (1993) reported on play behavior in juvenile and adolescent gorillas. Although no quantitative data was available, it was their impression that male gorillas played more than females. Juvenile and adolescent gorillas played mostly with age-sex peers. Play between male gorillas usually stopped as they became mating rivals.
In captive gorillas, Hoff et al. (1981) observed that reciprocal mother-infant play began in the fourth month. It was both initiated and terminated by the mother and consisted mainly of gentle nudging, mouthing, and wrestling. Mother-infant play occurred at a rate of .01 intervals per test in the fourth month, increasing to 1.6 intervals per test in the tenth month. This level remained relatively constant over the next several months and then dropped to .6 intervals/test after the 18th month. Infants began to approach one another in the fifth month. These interactions initially involved contact examination but evolved into active and moderate forms of play by the eighth month. Active play, often referred to as "rough and tumble" play, consisted of chasing, lunging, tackling, wrestling, falling on one another, and mock-biting. Moderate play was less active and consisted of lying on one's partner, light bouncing, mild pulling and tugging, etc.

As with wild gorillas, mothers were initially very vigilant during peer play sessions and frequently interrupted play bouts until the ninth month. Play sessions usually occurred on "neutral ground," i.e., between mothers but within 10 feet of them. Through the eighth and ninth month of life, mothers followed infants and sat near them as they played. During months 10 to 20, mothers showed less concern and maintained far less proximity when infants played with peers. By the 13th month, infants often played 50 to 60 feet from their mothers.

In a study of 19 captive gorillas ranging in age from 4 to 26 years, Brown (1988) found that play continued at fairly high frequencies through adolescence, but that juveniles played the most and with the largest variety of partners, including juveniles, adolescents, and adults. Dyadic play bouts were by far the most common, but occasionally triadic play bouts occurred when animals chased and charged each other in turn. Gorillas were never seen to play in groups larger than three. Male and female gorillas did not differ in the frequency of their play bouts, or in the type of play they engaged in; that is, active vs. moderate play. However, they did exhibit sex differences in partner preference. Males played with both males and females, while females seldom played with other females. Similar findings have been obtained in other studies of captive gorillas (Fischer and Nadler, 1978; Gomez, 1988) and are consistent with the social skills hypothesis proposed by Baldwin and Baldwin (1974). Simply stated, this hypothesis predicts that animals should preferentially play with partners similar to those with whom they form social relationships as adults.

Meder (1989) examined social play in both hand-reared and mother-reared gorillas ranging in age from 6 months to 5 years. It was found that in hand-reared infants living in heterosexual pairs, males initiated far more play than females, with rates especially high at about the 18th month of age. Hand-reared infants living in groups initiated more play than those living in pairs. Mother-reared infants played more than hand-reared groups. Meder suggested that hand-reared infants be kept in groups rather than pairs whenever possible, in part because of the wider variety of social experience available through play with more than one individual.

The frequency of social play appears to be greatly influenced by the social composition of the group, as was demonstrated by the LAZ gorillas. All three mothers initiated play with their infants at approximately 2 months of age. Thereafter, the development of play in infants "Angel" and "Kelly," who were peers, followed a pattern similar in some respects to that described by Hoff et al. (1981). When "Angel" and "Kelly" were 5 and 8 1/2 months of age, respectively, they began to play extensively with each other in close proximity to their mothers. Early in the second
year, as "Sandy," "Angel's" mother, became less protective of her, play between the two infants increased dramatically and became much more active.

Infant "Jim," who had no peers, did not approach the play frequencies of the other two infants until he was 20 months old. During the first year of "Jim's" life, his mother, "Evie," refused to allow him to play with other group members although they tried to initiate play. "Jim" played only with his mother. At the age of 15 months, "Jim" was first allowed to play with another adult female, and to a smaller extent, with other group members, including the silverback. Although "Jim" participated in far less social play than the other two infants, he did experience an interesting form of "vicarious play." For the most part, "Evie" avoided the group's rambunctious adolescent male, but occasionally she did play with him. While she wrestled and play-chased with this male, "Jim" clung tightly to her ventrum. So although the infant was not an active participant, he did experience some of the features of play second-hand.

Contrary to the findings of Hoff et al. (1981), at LAZ the frequency of play between infants and peers, as well as between infants and other group members, did not drop off by the 18th month but continued to increase with some fluctuations until at least the 24th month.

Survey results indicated that social play was first observed in females ranging in age from 2.0 to 8.0 months, with a median age of 5.0 months (n=5). Social play was first observed in male infants ranging in age from 1.5 to 24 months, with a median age of 5.0 months (n=11). It is not clear whether respondents considered social play to be mother-infant play or peer play.

**ADULT FEMALE-INFANT INTERACTION**

Immature female mountain gorillas are particularly interested in young infants and will peer at and touch them when allowed to do so by the mother (Watts and Pusey, 1993). However, Fossey (1979) reported that, overall, infants spent less time in close proximity to adult females than any other age/sex class. Only two observations were made of a female with an infant of her own attempting to hold and groom another female's infant. According to Fossey, infants over the age of 2 years went out of their way to avoid dominant females but tended to ignore lower-ranking females. Watts and Pusey (1993) presented data that indicated that immature males associated with adult females more than did immature females, and that males associated more with adult females as they approached adulthood. Both male and female juveniles and adolescents spent more time near related females than nonrelatives.

In the LAZ gorillas, adult females appeared very interested in infants not their own and interacted with them at levels dependent on the mother's restrictiveness. Infants "Angel" and "Kelly" often played with each other while in contact with any of the adult females. All females were seen to carry infants not their own. "Cleo" sometimes carried "Sandy's" infant and "Sandy" sometimes carried "Cleo's." Occasionally a mother would carry both infants at the same time, one riding dorsally and the other ventrally. Two adult females without infants of their own were also observed to carry infants and to interact with them in friendly ways. All infants interacted with their own mothers more than with others in the first year, but interactions with others increased, by varying degrees, in the second year. Due to his mother's restrictiveness, infant "Jim" interacted with other females far less than did the other two infants. Infant "Kelly," whose
mother was the most laissez-faire, actually interacted more with other females than with his mother in the second year.

These findings are contrary to those of Fossey (1979) and are similar to observations of captive chimpanzees. Captive chimpanzees also frequently carry infants not their own (Savage and Malick, 1977). The greater frequency of infant-adult female interactions in captivity, as compared to the wild, may be due to the greater proximity maintained by all group members in the relatively confined conditions of captivity. Captivity generally affords animals more opportunity to interact with one another, and less opportunity to avoid each other.

**ADULT MALE-INFANT INTERACTION**

In the wild, interactions between infants and blackback males are rare and usually limited to sibling associations (Fossey, 1979). Schaller (1963) did not observe any blackback-infant interactions.

However, infants associate more with silverback males (presumably their fathers) than with adult females who are not their mothers. Fossey (1979) found that interactions between silverbacks and infants increased with the age of the infant, with the largest increase occurring in the third year. Schaller (1963) also reported that infants were very attracted to the dominant male and that during rest periods one or more infants often sat by the male or played with him. Even when play became exuberant and rough, silverbacks remained remarkably tolerant.

The silverback's propensity for paternal behavior was demonstrated in a case of infant adoption described by Fossey (1979). Following the death of its mother, a 3-year-old female became extremely depressed. However, the silverback slowly assumed a maternal role, allowing her to share his night-nests. He became very protective, and spent considerable time grooming and cuddling her.

Although data were not presented, it appears that mothers and/or infants were primarily responsible for maintaining the high level of association with the silverback. In fact, Fossey (1979) referred to the silverback as a social "magnet" of sorts. Schaller's (1963) observations also suggested that infants initiated social interaction with silverbacks whereas silverbacks were rather passive recipients. Interestingly, infants of females who were more independent and less inclined to seek the proximity of the silverback, also spent less time interacting with him. The ramifications of this are unknown, but Harcourt and Stewart (1981) found that males who maintained a close relationship with the silverback during infancy and adolescence were more likely to stay in their natal groups.

Watts and Pusey (1993) reported that juvenile male gorillas continued to interact affiliatively with silverbacks, but as they grew older, proximity declined and silverback aggression increased. This pattern commonly preceded adolescent male emigration. Immature female gorillas also spent less time near silverbacks as they got older, but this stopped at adolescence and females continued to interact affiliatively with silverbacks.

Contrary to the field reports, observations of the three captive Yerkes infants indicated
that the silverback was not a passive recipient of their attentions. This male was extremely interested in infants and made repeated attempts to examine and play with them (Hoff et al., 1981). Of the total contacts between the silverback and the infants, 87 percent were initiated by the silverback (Wilson et al.; cited in Maple and Zucker, 1978). According to Hoff et al. (1981), the silverback's persistence in seeking contact with infants resulted in increased maternal protection and restrictiveness. In a study of the same captive infants, Tilford and Nadler (1978) found that the frequency of adult male-infant interactions was directly related to the strength of the affiliation bond between the adult male and the respective mothers. Although the silverback approached and touched all three infants, he initiated significantly more interactions, including dorsal-ventral riding, with one particular male infant. The silverback also affiliated with this infant's mother significantly more than with the other mothers. The authors suggested that under natural conditions, affiliative bonding promotes paternity confidence, which, in turn, increases the likelihood that males will invest in the care of offspring.

Maple and Hoff (1982) suggested that infants provided novel and compelling social stimuli, and that the captive silverback's interest in them was, at least in part, due to boredom. Data that support this theory were obtained in a study of adult male-infant interactions in a group of gorillas at the Woodland Park Zoo (Mitchell, 1989). It was found that two adult males interacted infrequently with an infant when housed in a cage with many objects. When housed in a cage with few objects, the males repeatedly attempted to make contact with the infant and the mother usually thwarted such interactions. Males performed playful and caregiving behaviors toward the infant but were also seen to use it as an object in excited display and in ways to tease the mother--clearly not beneficial behaviors. These findings point to the importance of providing captive gorillas with enriched environments. Rather than removing males from social contact with infants, Mitchell suggested that stimulation be provided in the form of a variety of interesting toys and objects to manipulate.

The silverbacks in the two LAZ groups each expressed mild curiosity in their newborn infants. The mothers "Evie" and "Sandy," avoided the silverback, whereas "Cleo," the most casual of the three, approached the silverback and literally thrust her infant in his face. However, she retreated if he attempted to touch the infant. Over the course of the next several months, mothers became less restrictive and allowed the males to briefly touch and inspect infants. Toward the end of the first year, infants "Kelly" and "Angel" were observed to engage in gentle play with the silverback; "Evie" continued to restrict her infant "Jim's" interactions. During the second year, all infants approached the silverback more often than the reverse. "Jim" began to play with the silverback, as well as other group members, late in the second year. The behavior of the LAZ silverbacks resembled Fossey's description, that is, passive, gentle, and tolerant. Males were never observed to carry infants, and contact other than gentle play was not extensive.

**SOCIOSEXUAL BEHAVIOR**

The literature on sociosexual behavior in pre-adolescent gorillas is not extensive. Schaller (1963) reported that he saw no sex-related behavior in immature gorillas, and although
Fossey (1979) observed copulatory behavior in infants and juveniles, she provided minimal descriptive or qualitative data. Some initial data were provided in articles by Harcourt et al., (1980, 1981), but most information has come from Nadler's (1986) study of sex-related behavior in immature wild gorillas and Hess' (1973) qualitative description of sexual behavior in a captive group of lowland gorillas at the Basel Zoo. Considering the difficulties of breeding gorillas in captivity, more research on the development of sociosexual behavior is needed.

**GENITAL INSPECTION**

Genital inspection/manipulation is the first sexually related behavior to occur in an infant's life. Hess (1973) reported that captive mothers undertook careful and extensive inspections of their newborns. Regions of special interest included the ears, face, shoulders, hands, feet, navel, and especially the ano-genital area. Genitals were stroked, plucked at, poked, held, mouthed, and sucked. During the first few days of life, such stimulation sometimes resulted in urination and defecation. From the second or third day, it resulted in erection. Male infants were reported to elicit more interest and exploration from mothers than female infants. The frequency of genital inspection declined as infants grew older but was observed fairly frequently through the third year, and only sporadically after that.

Maple and Hoff (1982) also observed maternal manipulation of infant genitalia in their study of the three Yerkes infants. However, this behavior occurred infrequently after the first month, and they found no sex difference in the rate of genital inspection by mothers. Infant-infant sexuality also began with genital exploration, including both manual and oral manipulations. High rates of ano-genital inspection were also seen in the two LAZ infants "Angel" and "Kelly." This typically occurred during bouts of play and greatly increased in frequency after the first year. Ano-genital inspection by adults other than the mother occurred at very low rates. The silverback was first observed to inspect the ano-genital region of his daughter when she was 9 months old. After inspection he sniffed his fingers. On only one occasion was an infant seen to sexually inspect its mother. When "Kelly" was 21 months old, his mother lay on the ground in front of him with legs spread; he then sniffed and touched her genitals. Nadler (1986) never observed immature wild gorillas to show any interest in the genitales of adults.

**SELF-EXPLORATION/MASTURBATION**

Hess (1973) reported that during the first few weeks of life, an infant was seen to explore its genital region using the hands in "scratching or palpating excursions." Touching of its own genitals sometimes caused an erection. Hess strongly stated that such behavior was not masturbation and that masturbatory behavior was not observed in infants under 2 years of age. Nadler (1986) observed only one episode of genital self-stimulation in a wild 10-year-old male. Although masturbation is relatively common in captive adult gorillas, this author knows of no published reports describing masturbation in pre-adolescents. Masturbation was first observed in the LAZ infants "Kelly" and "Jim" at 8 months and 17 months of age, respectively. It was not observed in the female, "Angel," until she was 6 years old and beginning to cycle.
PELVIC THRUSTING

Reflexive pelvic thrusting has been observed in infant chimpanzees; it is initially directed toward some part of the mother's body, usually the foot or knee (King, 1992). This behavior has not been described in gorillas. Typically, pelvic thrusting is first performed by infants in the context of playful mounting behavior. Both ventro-ventral and dorso-ventral positions are used.

MATERNAL MOUNTINGS

Hess (1973) reported that during an infant's first three years the mother repeatedly laid the infant on its back and then squatted over it while making rhythmic pelvic movements. Maple and Hoff (1982) also observed this type of ventro-ventral mounting by mothers in the Yerkes group. "Cleo" was the only LAZ gorilla observed to perform this behavior. It was first seen when her son, "Kelly," was 2 months old and occurred infrequently after that. Maternal mountings of infants have not been reported in wild gorillas.

PLAYFUL COPULATORY BEHAVIOR

In mountain gorillas, sociosexual behavior involves all age/sex combinations. Watts (1990) reported that all age/sex classes initiated mounts and all but silverbacks were mounted. Blackbacks and young silverbacks initiated most of the mounts and mostly mounted juveniles and subadults. Subadult and juvenile females initiated 19 percent of observed mounts, all of infants. The youngest animal seen to mount and thrust against another was a 26-month-old female.

Nadler (1986) found that the most common form of genital stimulation in immature mountain gorillas involved episodes of pelvic thrusting. These episodes occurred when one animal (the actor) pressed its genitals against those of another (the recipient) while making rhythmic pelvic movements. Pelvic thrusting was observed in immature gorillas ranging in age from 0.7 to 10.7 years and always occurred within the context of play: wrestling, chasing, embracing, and restraining. In almost all cases, the recipients were younger than the actors. The most frequent recipients were infants between the ages of 0.7 and 1.3 years. The youngest actor was a 2.3-year-old male. Nadler found that males were the actors in the majority of cases, initiating 80 to 90 percent of pelvic-thrusting episodes. However, one 5.4-year-old female was also seen to be an actor. Immatures performed pelvic thrusting in the following combinations: female-female, male-male, and male-female. Episodes of females pelvic thrusting against males were not observed.

Males were observed to perform pelvic thrusting in the dorso-ventral and the ventro-ventral position, although the dorso-ventral position was much more commonly used. Females only used the ventro-ventral position. This is consistent with normal copulatory behavior of male adults, which predominantly use the dorso-ventral position. Adult females have been observed to use the ventro-ventral position in encounters with other females. Pelvic thrusting episodes were brief, usually consisting of two to three thrusts. Intromission was never observed and was thought not to occur, due to small penile size in young male gorillas.
Similar episodes of pelvic thrusting have been observed in captive, immature gorillas, suggesting that these forms of genital stimulation are part of species-typical development (Nadler, 1986). Hess (1973) referred to these behaviors as play copulations. A female 1 1/2 years old was first mounted dorso-ventrally by a 5 1/2-year-old male. She, in turn, was seen at the age of 2 years to perform pelvic thrusting against the back of another animal, her mother. Maple and Hoff (1982) also observed pelvic thrusting during play in the Yerkes infants, beginning at about 1 year of age. These behaviors were awkward at first, with the infant inappropriately thrusting against another's stomach, legs, arms, or back. Over the course of the next few months, however, thrusting technique improved and included manipulating the partner and appropriate ventro-ventral and dorso-ventral positioning. More than 70 percent of pelvic thrusting episodes involved male-female combinations; the remainder involved male-male combinations.

Pelvic thrusting was observed in the LAZ infants at a very early age. When the male, "Kelly," was 8 1/2 months old, he was first seen to grasp the 5-month-old female, "Angel," from the rear and perform pelvic thrusting movements. These episodes always took place during playful encounters, usually gentle wrestling, and increased in frequency with age. Interestingly, pelvic thrusting was only mildly clumsy at first; orientation was usually correct. Contrary to Nadler's (1986) findings in wild gorillas, we observed that early in "Angel's" second year, the two infants began to reverse roles. Typically, "Kelly" would initiate episodes and perform pelvic thrusting in the dorso-ventral position. Then "Angel" would turn and perform pelvic thrusting in either the dorso-ventral or ventro-ventral position. Such reversals often occurred several times during play bouts. "Kelly" was not observed to mount "Angel" in the ventro-ventral position. While playful copulatory behavior between "Angel" and "Kelly" was almost a daily occurrence, infant "Jim" engaged in sexual behavior only rarely in infancy, probably because of the lack of peers. "Jim" was first observed to be mounted at the age of 29 months by the adolescent male. At the age of 31 months, he was first observed to initiate pelvic thrusting in the dorso-ventral position with a newly introduced 5-year-old female. However, subsequent sexual encounters were infrequent.

On one occasion when "Kelly" was 4 years old, he was observed to mount his mother dorso-ventrally and perform pelvic thrusting movements for 30 seconds.

POSITIONING PARTNER

Beginning in the second year, chimpanzees have been observed to very deliberately correct the positions of partners during sexual encounters (King, 1992). Maple and Hoff (1982) mentioned that as gorilla infants grew older, they "manipulated" partners for appropriate ventro-ventral and dorso-ventral positioning. No other reports contain descriptions of these behaviors in young gorillas. Positioning was not obvious in the LAZ infants, although this could have been an oversight on the part of observers. Occasionally, the male infant restrained the female if she attempted to leave when being dorso-ventrally mounted. Although he succeeded in drawing her closer to him, she was generally already oriented in the correct position.

SEXUAL PRESENTATION
Chimpanzee females are observed to competently perform sexual presentations (crouching) before 26 months of age (King, 1992). Information on the development of sexual solicitation behavior in gorillas, however, is scanty. Nadler (1986) reported that no presenting of the hindquarters was seen in immature males or females, nor did he describe any other forms of sexual solicitation. Hess (1973) reported that an older female infant showed forms of "offering" behavior towards her father while playing. He did not describe her behavior, but in adults, "offering" typically involves sexual presentation in a crouched or supine position.

In the LAZ infants, pelvic thrusting behaviors were abruptly performed in the midst of play bouts, seemingly without preliminaries. Typically, one animal would suddenly grasp the other, or the female would back into the male's lap or sit on him, and pelvic thrusting would commence. At the age of 27 months, the female, "Angel," directed her first sexual presentation to a silverback in an adjacent exhibit. She climbed to the top of a tall tree planter where she was clearly visible to him, and then crouched and slightly wiggled her hindquarters. "Angel" was not seen to present to the infant, "Kelly," until she was 3 years old.

Sexual solicitation in which a female gestures toward another with an extended arm and open palm was not observed in the LAZ infants. Maple and Hoff (1982), however, reported that infants use this gesture during play and that it may function to mediate contact. However, at the age of 4.5 years, "Angel" was first seen to "pronk," an unusual form of sexual solicitation that involved bouncing up and down on all fours. This behavior was directed at "Kelly" and occurred just after they had engaged in a play copulation. Interestingly, pronking is a form of sexual solicitation most often shown by "Cleo," "Kelly's" mother.

It may be surmised from the behavior of the LAZ gorillas, and from the lack of reports in the literature, that female sexual solicitation behaviors develop after infants are already performing playful copulatory behavior. Such behaviors typically become evident at around 5 years of age, when females begin to cycle. At this age, the frequency of pronking and play presenting dramatically increased in the LAZ gorillas (see section on adolescent development). It is interesting to note that although male infants tend to initiate more play copulation than females infants, females tend to initiate more sexual activity than males when they mature. Keiter and Pichette (1979) reported that 80 percent of copulatory activities between captive subadults was initiated by females in estrus. Watts (1991) reported that 63 percent of copulations in wild gorillas were initiated by the female.

SEXUAL DISPLAY

The lack of published reports make it difficult to determine when immature males develop forms of sexual display. Adult males sometimes display to females in estrus by performing the stiff-legged posture and/or strutting run. Chest-beating and hooting may also occur, and males may strike females as they run past (Dixon, 1981). The LAZ infant, "Kelly," was first observed to chest beat at the age of 9 months, but this was not associated with sexual activity. It appears that courtship behaviors used by male as well as female gorillas may not emerge until early adolescence, although additional documentation is needed to substantiate this.
SURVEY RESULTS

Table 1. Median age (years) of first occurrence of socio-sexual behavior. (Number in parentheses indicates sample size. Numbers in brackets indicate range.)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genital inspection/manipulation</td>
<td>3.0 (14)</td>
<td>4.5 (6)</td>
</tr>
<tr>
<td></td>
<td>[0.5-6.0]</td>
<td>[1.0-8.0]</td>
</tr>
<tr>
<td>Masturbation/genital stimulation</td>
<td>2.8 (9)</td>
<td>6.0 (7)</td>
</tr>
<tr>
<td></td>
<td>[0.6-5.0]</td>
<td>[3.3-10.0]</td>
</tr>
<tr>
<td>Pelvic thrusting</td>
<td>2.5 (15)</td>
<td>5.0 (5)</td>
</tr>
<tr>
<td></td>
<td>[0.5-6.0]</td>
<td>[0.9-8.0]</td>
</tr>
<tr>
<td>Dorso-ventral mounting</td>
<td>3.0 (13)</td>
<td>5.0 (5)</td>
</tr>
<tr>
<td></td>
<td>[0.5-7.0]</td>
<td>[2.0-8.0]</td>
</tr>
<tr>
<td>Positioning of partner</td>
<td>3.0 (10)</td>
<td>5.0 (4)</td>
</tr>
<tr>
<td></td>
<td>[0.5-8.0]</td>
<td>[2.0-8.0]</td>
</tr>
<tr>
<td>Sexual presentation</td>
<td>3.0 (5)</td>
<td>5.0 (7)</td>
</tr>
<tr>
<td></td>
<td>[0.5-6.0]</td>
<td>[3.0-8.0]</td>
</tr>
<tr>
<td>Sexual solicitation</td>
<td>5.5 (4)</td>
<td>5.0 (7)</td>
</tr>
<tr>
<td></td>
<td>[3.0-7.0]</td>
<td>[4.0-8.0]</td>
</tr>
</tbody>
</table>

IMPLICATIONS FOR CAPTIVE MANAGEMENT

RESULTS OF MATERNAL DEPRIVATION

The information provided in this chapter has a direct bearing on the husbandry of captive gorillas. As previously stated, there is ample evidence from studies of primates to indicate the importance of early experience in social development and the detrimental effects of maternal deprivation (Mason et al., 1968; Turner et al., 1969; Riesen, 1971; Nadler, 1981). According to Beck and Power (1988), hand-reared gorillas, especially those with limited access to conspecifics early in life, experience moderate to severe social deprivation. It is, therefore, strongly suggested that young gorillas be raised by their mothers, and that they be hand-reared only in life-threatening situations.

Maternal Competence

As previously stated, poor maternal care in captive gorillas has been an issue of great concern. Until recently, approximately 80 percent of captive-born gorillas were removed for hand-rearing due to observed or anticipated maternal incompetence (Nadler, 1974). Because
hand-reared infants grew up without maternal experience, it was expected that they, in turn, would be poor mothers. Consequently, some of their offspring were removed for hand-rearing as well.

Data from subsequent studies have provided arguments against the belief that inexperienced females will be poor mothers. Beck and Power (1988) surveyed the North American gorilla population and found that the probability of a female being a competent mother was not affected by being wild born or captive born, or mother reared or hand reared. [However, they also noted that hand reared females were less likely to be reproductively successful.] Nadler (1974) observed that first-time mothers that had never observed an infant being reared were fully capable of rearing their own offspring. This was confirmed by observations of the LAZ gorillas. The three mothers, "Sandy," "Cleo," and "Evie," had no prior experience with infants. "Cleo" and "Evie" were both hand reared and thus grew up without experiencing maternal care from a gorilla. "Sandy," a wild-caught female, was presumably removed from her mother in infancy, so her early experience was limited. Yet all three mothers capably cared for their newborns.

Although competent, each LAZ mother displayed a unique mothering style. Indeed, throughout this chapter, variability has been noted in the behavior performed by gorilla mothers. At LAZ, differences were evident in nursing onset and later weaning, idiosyncratic forms of maternal transport, and variability in time spent in contact and/or proximity. It appears, therefore, that a wide range of maternal behaviors may fall within the norm for gorillas.

The above should not be taken as recommending the hand-rearing of gorillas. Several studies have shown that maternal proficiency increases with experience (Nadler, 1974; Stewart, 1977). In the LAZ gorillas, improvement in maternal technique was quite evident in the two mothers "Sandy" and "Evie" ("Cleo" was considered "textbook perfect"). Within the first few days, these females learned to correct their mistakes and to make adjustments in infant handling that allowed for more effective nursing and transport. Stewart (1977) noted that infant gorillas vocalized shortly after birth and that mothers responded by adjusting their behavior to meet the demands of the infants. It thus appears that mothers are capable of fine-tuning their caregiving behaviors and that they learn to do this, to some extent, from their own infants. Taken together, the evidence suggests that caution should be taken against the premature removal of infants for hand-rearing. As Miller-Schroeder and Paterson (1989) stated, "the time has come to ask if more flexibility is not needed in evaluating maternal competence."

It is evident that gorillas do not need to learn specific maternal behavior patterns from other gorillas before they can rear offspring. Instead, they appear to be genetically predisposed to be maternal under certain physiological, environmental, and social conditions, which in the wild are normally met. Determining the nature and importance of these conditions remains a major challenge for those involved in captive management. A variety of factors have been proposed to influence the probability of maternal success in captivity, but data are badly needed to substantiate causal relationships (see Miller-Schroeder and Paterson, 1989; Bahr, 1995) for extensive reviews). Aspects of the physical environment that may influence maternal competence include cage size and amount of vertical space; access to privacy; opportunities for activity, play, and exploration to reduce stress and boredom; access to live vegetation; access to nesting material; and diet. Important social factors may include group composition; maternal
rank and temperament; access to familiar companions; sex of infant; and relationship to human caretakers. Contributing physiological factors may include maternal health; adequate milk production and ability to nurse; and endocrine factors.

**Benefits of Maternal Rearing**

Although hand-rearing does not appear to affect the probability that a female will be a competent mother, it can affect the probability that she will successfully breed in the first place. As mentioned previously, Beck and Power (1988) found from their survey of North American gorillas that mother-reared females were reproductively more successful than hand-reared females. (This difference was not seen in males, although it was noted that sample size was small). It was shown that unsuccessful females exhibited behavioral deficits: they were less likely to present to males, exhibit other proceptive behavior, and to copulate. Social access to other gorillas during the first year of life improved a hand-reared female's chance of successful breeding, but not to the extent of mother-reared animals.

In addition to producing animals that exhibit functional copulatory behavior, maternal rearing may benefit animals in other ways. Meder (1989) compared the behavior of hand-reared and mother-reared immatures and found that hand-reared animals showed significantly more aggression and less social play than mother-reared ones, especially when raised in pairs as opposed to groups. It was also found that hand-reared gorillas, especially males, frequently directed aggression indiscriminately against conspecifics when later introduced to them. Meder suggested that this was a consequence of having been deprived of the opportunity to learn how to adjust behavior toward older, larger animals.

Hand-reared infants performed a number of stereotypic behaviors, including finger-sucking and rocking (rhythmic back-and-forward or up-and-down movements of the rump) during the first year of life; none of the mother-reared gorillas showed these behaviors. Insufficient opportunity for sucking was suggested as an important cause of finger-sucking. Mother-reared infants, of course, spend considerable time suckling at the mother's breast, usually well into the third year of life. According to Meder, lack of vestibular stimulation has been proposed as a cause of rocking behavior. Hand-reared infants are carried and held by human caretakers far less than naturally reared infants, which have almost constant body contact with their mothers during the first few months of life. The lack of vestibular stimulation that results from being moved and carried about may be a significant form of deprivation for hand-reared infants.

**Group Composition**

Captive social groupings that closely approximate those found in the wild will best promote the development of natural species-typical behaviors in gorillas. Groups should contain peers, unrelated adult females, and a dominant adult male. As previously mentioned, Beck and Power (1988) found that social access to conspecifics in the first year was associated with increased reproductive success in females. In the LAZ study, it was demonstrated that while maternal restrictiveness affected the rate at which infants interacted with others, infants did participate, to varying degrees, in playful and social encounters with others, including adults. This was most pronounced in the first year of life.
Although peer-rearing helps to ameliorate the deficits of maternal deprivation in hand-reared infants, it does not replicate the wide variety of social interactions seen in groups with animals of different age/sex classes (Beck and Power, 1988; Meder, 1989). Even when infants do not participate directly in social interactions within the group, they most certainly observe the behavior of others. Data are needed to substantiate the role of observational learning in young gorillas, but it is intriguing to note that in chimpanzees, infants that have an opportunity to observe adults copulate are much more likely to show successful copulatory behavior in adulthood (King, 1992). Fossey (1979) noted that infants at the age of 24 to 36 months showed significant awareness of other group members and were interested in the copulations of adults. Similar curiosity in the copulatory behavior of adults was seen in the LAZ infants.

There were also several interesting instances of mothers participating in sexual activities while maintaining contact with their infants. Both "Cleo" and "Evie" were observed to carry their infants ventro-ventrally and dorso-ventrally while pronking (a form of sexual solicitation) toward silverbacks. "Sandy" was occasionally mounted dorso-ventrally by other adult females as she carried her infant ventro-ventrally. An adolescent male attempted to copulate with "Evie" while her infant clung to her ventrum. Consequently, observational learning may have been brought to a new level in these groups.

Beck and Power (1988) suggested that deficits in gorilla sexual behavior may be the result of subtle abnormalities in communication, not easily recognizable to human observers. Courtship behavior in gorillas appears to be especially complex, marked by tension and ambivalence. It seems quite likely that the social experience provided in a naturalistic group enables a young gorilla to become a better "communicator," i.e., better able to send appropriate signals to others and better able to read and respond to signals--skills integral to successful breeding.

RECOMMENDATIONS

Although further studies on behavioral development in gorillas are urgently needed to determine the precise effects of early experience, the existing data have strong implications for improved captive management. A number of recommendations have been made regarding the provision of conditions conducive to successful maternal care and infant socialization. They are summarized as follows:

1. Gorillas should be maintained in naturalistic social groups with a variety of age-sex classes.

2. Gorillas should be housed in large, environmentally enriched enclosures. Visual barriers, access to privacy, climbing apparatus, vegetation, nesting material, and manipulable objects are important in reducing stress and boredom in mothers (Miller-Schroeder and Paterson, 1989). Manipulable objects may be a helpful source of diversion for adult males when infants are present (Mitchell, 1989).

3. Pregnant females need an adequate diet, including possible vitamin and mineral supplementation. Health problems concerning nursing, especially engorged
breasts and sore nipples, need to be treated (Miller-Schroeder and Paterson, 1989).

4. Females should remain in their social groups during pregnancy, following birth, and during infant rearing. The presence of other group members may serve as a buffer against stress (Miller-Schroeder and Paterson, 1989).

5. Infants should not be removed for hand-rearing unless there is a significant threat to the health of the mother or infant (Beck and Power, 1988). Care should be taken against the premature removal of infants due to anticipated or perceived maternal incompetence. Inexperienced gorillas have proven to be competent mothers, and many gorillas show improvement in maternal care during the first few days of an infant's life.

6. If infants must be hand-reared, they should be kept with other infant apes, preferably gorillas (Beck and Power, 1988).

7. Hand-rearing infants in peer groups is preferable to raising them in pairs, because they will find more varieties in social contacts (Meder, 1989).

8. Hand-reared infants should be integrated into social groups containing adults as soon as possible, preferably by about 1 year of age (Beck and Power, 1988; Meder, 1989).

9. Hand-reared infants should have a human caretaker who provides a base of security and ample physical contact (Meder, 1989).
INTRODUCTION

For the animal manager that needs to prevent reproduction, three basic options are available: 1) separation of the sexes, 2) reversible contraception, and 3) permanent sterilization. Selection of the most appropriate birth control method should be based on: its efficacy and safety in gorillas and/or related species, the medical history of the individual animal, behavioral considerations, management/logistic factors, and the reproductive future of the individual.

If the manager selects a reversible contraceptive, it should be understood that use of these methods in exotic species is, for the most part, still experimental. Consider that years of research are devoted to the development of a contraceptive method for humans, yet even after distribution, research is continued via retrospective studies. Development of contraceptive methods for the exotic mammals we manage in zoos is based on previous research with the product, the reproductive physiology of the species, the results of its use in related species (where applicable), and retrospective analysis of its use in that species.

In selecting an effective and safe birth control method for gorillas, humans represent an excellent model. Indeed, many of the reversible contraceptive methods used in great apes are contraceptives developed for women. Retrospective analysis of the use of all reversible methods of contraception in zoo mammals is ongoing through the AZA Contraception Database. Much of the information in this report is based on data from this database.

PERMANENT CONTRACEPTION: MALE AND FEMALE DIRECTED

VASEQUSTOMY

A chemical or surgical vasectomy permanently sterilizes a male without the loss of steroidogenesis. Normal male behavior, including breeding behavior, is not affected by a vasectomy. A vasectomized male should be prevented access to a reproductive female for at least 30 days after the procedure. When carried out by an experienced and skilled surgeon, the procedure can be reversed in humans. To date, this has not been tried in gorillas.

CASTRATION

Castration is a surgical procedure that removes the testicles and, consequently, the production of testosterone. The resulting effect on the behavior of the male will be partially dependent on the age at which the male is castrated. Further research on the relationship between
the age of castration and the subsequent behavior of the male is needed.

**TUBAL LIGATION**

This surgical procedure ties the female's fallopian tubes, thereby preventing pregnancy but not the production of the sex steroids. The female will continue to exhibit normal menstrual cycles and concomitant sexual behavior.

**HYSTERECTOMY**

A hysterectomy is the surgical removal of the uterus without the removal of the ovaries. Thus, the female gorilla will not menstruate but should continue to exhibit normal sexual behavior.

**OVARIOHYSTERECTOMY**

This surgical procedure removes the uterus and the source of female sex steroids, the ovaries. The female will not menstruate and may discontinue exhibiting some or all components of sexual behavior. Again, further research on the relationship between the age of ovariohysterectomy and subsequent manifestation of sexual behavior is needed.

**REVERSIBLE CONTRACEPTION: MALE DIRECTED**

To date, there are no reversible contraceptive methods available to male nonhuman primates. Several male-directed methods are involved in research trials and are not currently available for general use. Some of the methods are described below for informational purposes.

**VAS PLUG**

A small silicone plug injected directly into both vas deferens. This method is used in human males and has been tested in a number of nonhuman primates. Successful insertion of the plug has been greater in large versus small primates. Several chimpanzees and one orangutan have received vas plugs. To date, the method has not been reversible in nonhuman primates.

**BISDIAMINE**

A chemosterilant that inhibits spermatogonial synthesis but not hormone synthesis. This method was shown to be effective in human males, but because of medical complications associated with the interplay of alcohol and bisdiamine, potential commercialization of the product was discontinued. Current research is centered around the use of bisdiamine in male carnivores and may extend to primates in the future. This method requires daily oral treatment.
REVERSIBLE CONTRACEPTION: FEMALE DIRECTED

Essentially all reversible birth control methods now in use are female directed. This section will provide cursory information on several methods involved in research trials and detailed information on methods used in orangutans.

IMMUNOCONTRACEPTION: PORCINE ZONA PELLUCIDA VACCINE

Research with the porcine zona pellucida vaccine has included nonhuman primates, but data on efficacy, reversibility, and long-term effects are not yet available. To date, the Contraception Advisory Group does not recommend this form of contraception in any individual that is needed for future reproduction. This is because further research is needed to determine if individuals administered long-term ZP treatment can be reversed.

MGA IMPLANT

Not commercially available, this implant was first developed and distributed by Dr. Ulie Seal. The MGA implant is now produced by Dr. Ed Plotka, 1000 N. Oak Avenue, Marshfield, WI 54449-1830. The MGA implant is made of a silicon rod that contains the synthetic progestin melengestrol acetate. The implants are distributed by weight, with MGA comprising 20 percent of the implant weight (i.e., a 5-gram implant contains 1 gram of MGA) (Plotka, pers. comm.). Institutions ordering the implant are requested to provide information on the female's body weight to allow for more individualized dosing. It is the most commonly used contraceptive in zoo mammals.

BIRTH CONTROL PILLS

Human birth control pills are available in different formulations, from the progestin-only pill to a variety of combined estrogen/progesterone pills. The human regime is 21 days of hormone treatment and 7 days of a placebo, a regimen that allows women to menstruate. The majority of great apes that have been contracepted with birth control pills have followed the same regimen.

NORPLANT

Norplant, developed for use in women, is a contraceptive implant that contains the synthetic progestin levonorgestrel. The Norplant kit, available through Wyeth, constitutes six slender capsules, each containing 36 mg levonorgestrel for a total dose of 216 mg. In humans, Norplant is said to be effective for five years. However, informational inserts distributed with Norplant kits indicate that the probability of failure increases in women over 110 lbs (failure
rates: < 100 lbs = .2; 110-130 lbs = 3.4; 131-153 lbs = 5.0; > 153 lbs = 8.5).

DEPO-PROVERA

Depo-Provera contains the synthetic progestin medroxyprogesterone acetate in an injectable form. This contraceptive method was recently approved by the FDA for use in women. The human dose is 150 mg every 90 days. An appropriate dose for gorillas is not known, but the human dose may be used as a starting point. Depo-Provera may be best used as an intermediate contraceptive method; e.g. it has been used in some old world primate species to contracept a female in between implant orders.

BIRTH CONTROL METHODS USED IN GORILLAS

To date, few gorillas have been contracepted, therefore data are limited. The AZA Contraception Database (1995 data) contains information for 11 females. Nine females were contracepted with birth control pills, one with an MGA implant, and one with Norplant (see Table 1).

Clearly, data on gorilla contraception are limited. Although 9 of the 11 females were contracepted with birth control pills, 5 different formulations were used and only 5 were contracepted for longer than a year (including one nonreproductive female). Only one MGA implant has been used, and to date it has been successful. The Norplant was removed after SSP recommendations were made to transfer the female and allow reproduction. The implant was reportedly very difficult to remove.

Data for the other great ape species show the MGA implant to be a reliable contraceptive in both orangutans and chimpanzees. Of the 24 and 94 MGA implants used in chimps and orangutans respectively, none have failed. However, implant losses have resulted in one chimpanzee and two orangutan pregnancies. Norplant has been used in both species, but the sample size and duration of use is still small (11 chimps, 12 orangutans). Preliminary data suggest that duration of efficacy is shorter in chimpanzees than humans (Bettinger, pers. comm.). Species differences are not unexpected, and the manager considering Norplant should monitor the estrous cycle of the implanted female.

Birth control pills have also been used to contracept chimpanzees and orangutans. The database contains information on 35 bouts of birth control pill use in chimpanzees involving 4 formulations. One female conceived when contracepted with Modicon 28 and again after 73 months on Ortho-Novum 1/50. Twenty-three bouts of birth control pill use in orangutans resulted in 4 pregnancies. One failure was confirmed due to the female missing five doses. Of the three other failures, keepers reported that the females were consuming their pills. Nevertheless, confirming daily intake can be difficult, especially in orangutans that seem to hold food or liquids in their mouths for long periods of time. Consequently, we cannot confirm whether the failures were dose or intake related.
Table 1. Birth Control Methods Used in Gorillas.

<table>
<thead>
<tr>
<th>Female</th>
<th>Method</th>
<th>Completed bout</th>
<th>Ongoing bout</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overette*</td>
<td>11 mo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lo-Ovral 28*</td>
<td>40 mo</td>
<td></td>
<td>Used for behavioral reasons, not for contraception, female never reproduced</td>
</tr>
<tr>
<td>3</td>
<td>Ortho-Novum 1/50*</td>
<td></td>
<td>34 mo</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Demulen*</td>
<td>1 mo</td>
<td></td>
<td>Used to regulate cycle</td>
</tr>
<tr>
<td>4</td>
<td>Demulen*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Demulen*</td>
<td>1 mo</td>
<td></td>
<td>Used to regulate cycle</td>
</tr>
<tr>
<td>6</td>
<td>Ortho-Novum 1/50*</td>
<td>16 mo</td>
<td></td>
<td>To prevent repro w/sire, successful</td>
</tr>
<tr>
<td>7</td>
<td>Ovcon 35*</td>
<td>9 mo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Ovcon 50*</td>
<td></td>
<td>1 mo</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ortho-Novum 1/50*</td>
<td>6 mo</td>
<td></td>
<td>Stopped for repro, but male was in ill health.</td>
</tr>
<tr>
<td>8</td>
<td>Ortho-Novum 1/50*</td>
<td></td>
<td>22 mo</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Ortho-Novum 1/50*</td>
<td></td>
<td>14 mo</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>MGA Implant</td>
<td></td>
<td>24 mo</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Norplant</td>
<td>5 mo</td>
<td></td>
<td>Removed, female transferred for repro. Difficult to remove, proc. took 1.5 hrs</td>
</tr>
</tbody>
</table>

*forms of birth control pills

**PRE-PUBERTAL OR JUVENILE CONTRACEPTION**

The AZA Contraception Advisory Committee has made the basic recommendation that contraceptive steroid treatment should not be initiated in pre-pubertal females. This is because
the paucity of data about pre-pubertal steroid treatment and potential long-term effects on fertility contraindicate steroid contraception before puberty. Determining the onset of puberty in female gorillas can be difficult, in that individuals mature at different rates. Females as young as six years of age have conceived. If possible, a manager should monitor the maturing female's urine to detect the onset of cycling.

**EVALUATION OF SIDE EFFECTS**

Assessment of side effects associated with the use of any reversible contraceptive method requires careful documentation before, during, and after contraceptive use. Proper evaluation requires the maintenance of accurate records and, upon the animal's death, a necropsy that thoroughly evaluates the reproductive and other associated systems.

**RECORDS AND THE CONTRACEPTION ADVISORY GROUP DATABASE**

It is incumbent upon the animal manager to maintain detailed and accurate records on all contracepted animals. Through the AZA Contraception Advisory Group (CAG), data on all mammals contracepted in North American zoos are being maintained in a single database. Compilation of these records into one database will obviously allow more accurate and thorough retrospective analysis of the efficacy, reversibility, and safety of the various contraceptive methods.

The CAG suggests that each institution develop a contraception record-keeping system to allow maintenance of timely and therefore more accurate records. Such records will also facilitate completion of the yearly CAG update surveys distributed in April and due July 1. Systematic records may also have the advantage of alerting the manager to any potential problems with a particular individual (weight gain, behavioral changes, method in use/place, etc).

Because the information listed below is requested in the contraception survey, the CAG suggests that the institution's records include the following:

1. Individual's ISIS #, studbook #, name, birthdate.

2. If the individual has ever reproduced and date of last offspring (live or stillborn).

3. Type of contraceptive method (brand name if appropriate, dose, if MGA then implant # and wt, etc. and how/where given).

4. Date of initiation.

5. Animal weight; accurate weights of the individual BEFORE and AFTER contraceptive use are very useful data.
6. Dates the contracepted individual has access to a reproductive mate (e.g. if a female is implanted and introduced to her mate 7 days later, that information should be recorded). If the birth control is ended, record the date the individual has access to a reproductive partner.

7. Date(s) the contraceptive method is ended and reason (ended to allow reproduction, to change to another method, to replace implant, mate died, medical complications, etc.).

8. Date of a birth: if the birth is UNPLANNED it is very important to confirm whether the contraceptive method was in use at the time of conception and/or parturition (e.g. was the implant in place or lost, did the female take all her pills, etc.). Record whether the infant was live or stillborn.

9. Note behavioral changes (if any), male or female initiated sexual behavior, dates of copulation, etc.

10. Note physical/physiological effects when applicable (changes in menstrual cycle, blood chemistry, etc.).

**PATHOLOGY RESEARCH**

Dr. Linda Munson, pathologist and member of the CAG, is engaged in research aimed at assessing the long-term effects of reversible contraception in carnivores and primates. Dr. Munson's study includes determining whether certain contraceptive methods cause irreversible changes in the uteri of carnivores and primates and if pathological responses vary by species and/or duration of contraceptive exposure. Every institution that houses gorillas can contribute to this important research by remembering to provide samples to Dr. Munson upon the death of a female.

Please note that there is a standing request for the reproductive tract of any female primate, REGARDLESS of the individual's contraceptive history. The reproductive tract should be prepared and sent to Dr. Munson at the address given below.

**DIRECTIONS:** Reproductive tracts from either necropsies or ovariohysterectomies would be appropriate. The tracts can be fixed in buffered formalin by immersion of the entire tract for 72 hours if a small incision is made into the lumen of the uterus in each horn. The ratio of tissue to formalin should be 1:10. Fixed tracts can then be wrapped in formalin soaked paper towels, enclosed in a leak-proof plastic bag and shipped by U.S. mail (Federal Express is NOT necessary). The package should be sent to:

Dr. Linda Munson
Department of Pathobiology
College of Veterinary Medicine
University of Tennessee
P.O. Box 1071
WEIGHT GAIN

Weight gain is one side effect that may occur with the use of contraceptive steroids. Indeed, because obesity can have serious health consequences, weight gain is an aspect of contraceptive use that should be carefully monitored by the animal manager.

RECOMMENDATIONS

The Contraception Advisory Group has issued birth control recommendations for mammals. Based on the available information, the recommendation for gorillas includes a choice of birth control pills, the MGA implant, and Norplant. To date, consumption of birth control pills has not been reported to be problematic in gorillas. Duration of MGA implant and Norplant efficacy in female gorillas is not known. The general recommendation that MGA implants be replaced every two years should serve as a guideline. Research on Norplant duration is needed. The individual health, immobilization risks, social situation, and facility design (ease with which birth control pills can be fed) should be factors that assist in determining the most appropriate contraceptive method for any particular female gorilla.
CARECARE
The relationship between gorillas and caregivers can be a close one, depending upon the personal philosophy, training, and attitude of the caregiver, as well as the institution's protocol. A close genetic relationship, coupled with the high intelligence of the gorilla, has inspired human fascination with the species. Because of this curiosity, gorillas have been studied extensively, and much is now known about wild gorilla behavior. Captive gorilla management has also progressed as more information has been gathered about species-typical behavior. One result is the clear need for complex physical and social environments for captive gorillas, and caregivers play an important part in this environment.

Information is also available to keepers in books, scientific journals, and an international gorilla newsletter, *Gorilla Gazette*, all of which serve to enhance a gorilla caregiver's knowledge and understanding of the species. Further, international gorilla workshops have brought together field researchers and ape keepers from different countries to disseminate information, which was previously difficult to obtain because of distance and language barriers. This communication between keepers is essential for the best possible care and husbandry of captive gorillas.

Philosophies differ around the world as to the level of caregiver interaction with gorillas. Some institutions allow keepers to enter the enclosures with the animals and have physical contact with them, other zoos prefer to minimize human/gorilla contact as much as possible, while most fall somewhere in between. Opinions also vary on the degree of control that should be exerted over gorillas, ranging from a great deal of control to allowing more freedom of choice.

**CAREGIVER QUALITIES**

A competent gorilla caregiver demonstrates many qualities that separate him or her from those keepers who are "just doing a job." The best attitude should be one of sensitivity and respect for the dignity of the gorilla. Knowledge and understanding of gorillas and their behavior is obviously mandatory, yet anthropomorphic generalizations and interpretation of behavior, while perhaps inevitable, may result in human bias in comparisons. The best caregivers have earned the trust and acceptance of the gorillas in their care through patience, compassion, and nurturing. This trust has two beneficial effects: facilitation of daily husbandry and reduction of stress for gorillas in their captive environment. Gentleness and consistency are important attributes. Further, the degree and type of sensory communication in all human/gorilla interactions are key to a close relationship. For example, sense of smell is an aspect of communication that the caregiver might overlook. Although gorillas may be interested in human scents, some caretakers report that gorilla olfaction may be negatively affected by excessive use of perfumes, bleach or soap. Similarly, gorillas react adversely to loud sounds and rapid movements of keepers, which can result in increased excitement levels and negative behavior among the gorillas. Conversely, squatting down to the level of a gorilla, avoiding direct stares,
and utilizing the soft contented "grumble" vocalizations of the gorilla can be very reassuring to the animal. A keeper who is noisy and intrusive will not have a close relationship with the animals and may cause or heighten disturbances within a group. On the other hand, a caregiver who has earned the trust of the gorillas can be a calming influence during times of stress, such as introductions, change in routines, or long-distance transfers.

Keen powers of observation are necessary to detect both medical problems and even slight changes in individual behavior or group social dynamics. The casual observer would not have the experience to notice or recognize many of these things; time is required for caregivers to learn the idiosyncrasies of individual gorillas. Awareness and understanding of a gorilla's needs, from obvious ones such as food or increased space to more subtle ones such as psychological well-being, can take years for a caregiver to learn. Although some zoos have a policy of keeper rotation, it is the opinion of many gorilla keepers that continuity and consistency among caregivers over time are very important in maintaining a healthy, stable population of gorillas. Familiarity breeds contentment in many cases.

**RELATIONSHIP**

Ideally, the gorilla/caregiver relationship is based upon trust and mutual respect. Caregivers should have empathy for these intelligent animals. While caring for gorillas, caregivers need constantly to be aware that they are responsible for dictating much of a gorilla's life in captivity. It is incumbent upon caregivers to provide the gorillas with a sense of security and a safe and healthy environment. Beyond that, it is imperative that gorillas be allowed to exhibit their own species-specific behavior and as much self-determination and freedom of choice as is possible in captivity. Gorillas should neither be overly dependent upon nor overly controlled by their caregivers.

It must be noted that the behavior of both gorillas and caregivers directly influences their relationship. Thus, caregivers affect and shape gorilla behavior and vice versa. Once human and animal get to know one another, certain expectations are formed from their combined past experience. Therefore, both caregiver and gorilla may be predisposed to a particular behavior in a given situation. This can be advantageous to caregivers when anticipating a gorilla's response to different circumstances. It can also be detrimental when gorillas are able to "condition" their caregivers to behave in a certain way without the latter's knowledge. For example, gorillas don't always conform to an exact schedule and may balk at shifting from one area to another. However, it is important to realize that any negative reinforcement (shouting, hosing, etc.) meted out by the keeper may result in social aggression, individual behavioral changes, refusal to move, and resentment toward caregivers. It could permanently damage the caregiver/gorilla relationship, and should only be used in an emergency.

Just as people have individual personalities, so do gorillas (Gold and Maple, 1994). Thus, the specific relationship between human and ape will vary from person to person, gorilla to gorilla. Gender of both caregiver and ape can influence a gorilla's behavior. This factor can directly impact adjustment time to a new caregiver. For example, many keepers have observed that a male gorilla may exhibit more aggression toward a man than a woman, possibly feeling a certain threat from a "new male" in his territory. Similarly, female gorillas may solicit for sexual
attention from human males and may take longer to accept women caregivers, perhaps perceiving them as possible rivals. Interestingly, female gorillas traditionally taken care of by a male keeper can be very jealous and aggressive toward new female caregivers in his presence. Conversely, male gorillas may display a certain amount of sexual behavior and vocalization toward female caregivers. This is distinctly apparent with the males in the St. Louis Zoo bachelor group. However, although gender may be a factor, the most important quality needed by a caregiver is consistency in positive, productive interactions.

**PHILOSOPHY**

There are many different philosophies on captive gorilla management and the role caregivers play. In general, such philosophies have not been documented as a formal protocol. In a survey sent to North American zoos exhibiting gorillas, 33 percent of 39 zoos surveyed have no formal policy for caregiver/gorilla interactions. However, philosophies tend to differ on the appropriate level of "human socialization" of gorillas. European zoos such as Howletts and Apenhuel allow keepers to enter enclosures containing an entire group of gorillas. Some caregivers carry on the close relationship with hand-raised infants well into young adulthood. These institutions may also allow some socialization between mother-reared infants and caregivers by establishing a "creep" situation, on the theory that this contact with caregivers will decrease stress in future management routines.

At the opposite end of the spectrum are zoos that allow little, if any, physical contact between keeper and gorilla and prefer to encourage only gorilla/gorilla social interaction. The majority of institutions probably choose a more moderate course: encouraging gorilla/gorilla social interactions, but allowing the establishment of some relationship between caregivers and gorillas through methods such as hand-feeding or through the use of systematic training methods. Establishing effective, consistent, positive reinforcement practices is critical. This is covered more fully in the training section of this manual. However, it is key to consider the philosophical role of reinforcement--for example, the desire to promote natural behaviors.

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

Rearing history has a significant influence on how gorillas relate to their caregivers. Hand-raised gorillas can be seriously imprinted on humans the longer they are in a nursery situation, especially if the youngsters are not raised in conspecific peer groups. Imprinted gorillas are socially inept with their own species and often prefer the company of their caregivers. In such cases, the hand-raised gorilla's experience with humans and its similar lack of experience with gorilla troop social behavior may impart a social standing to its caregivers that should be considered in decisions relating to the individual and troop. Generally, the closer the
bond between these gorillas and their keepers, the harder it is to mainstream them into a proper social group. Infants hand-reared with peers exhibit less imprinting on people; therefore, any sensory contact between a youngster and gorillas is important. In any case, a key factor is the age at which a hand-reared gorilla is reintroduced to a family group. The earlier the introduction takes place (i.e., prior to one or two years of age), the less likely youngsters are to show ill effects from being raised by caregivers. In some instances, parent-raised gorillas have been reported to be slightly standoffish toward their caregivers. Their social experience has been dominated by gorillas, not humans, and they regard their caregivers as just that.

Most zoos have gorillas numbering in the single digits, although some maintain large groups of 10 to 15 individuals. Taking care of a lone gorilla necessitates that the keeper have a closer relationship with the animal in order to prevent boredom and alleviate social isolation. The gorilla/caregiver relationship should take on a different approach, however, regarding large groups of gorillas. The importance of the bonds within the group must be recognized, and the keeper should take a step back. The gorilla/caregiver relationship takes on a different approach in these circumstances. Each group has its own hierarchy, determined at least in part by the silverback. Quarrels may break out concerning rank among the gorillas, and keepers walk a thin line as to when it is prudent to interfere. Gorillas must be given as much freedom as possible to control their own lives. The decision to step in should not be colored by human sentiment but rather by an appreciation of the gorillas' natural behavior, and the awareness that gorillas in the wild may experience difficult social circumstances.

There is great variation in zoo philosophies, husbandry programs, and caregiver techniques worldwide. Ideally, it would be of benefit to have a consistent philosophy concerning the gorilla/caregiver relationship across zoos. However, due to the diversity of opinion regarding such issues as degree of contact, this may not be possible. In the end, the caregiver's role must be recognized as an integral part of any successful husbandry program. Under often less-than-ideal circumstances, the caregiver must consider the needs of the gorilla paramount in the development and maintenance of an effective management plan.

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

**RECOMMENDATIONS**

1. Institute a keeper training program incorporating experienced caregivers teaching novices.
2. Maintain continuity of caregivers. Keepers should not be rotated in and out of the gorillas' lives.
3. Provide consistent care.
4. Recognize and encourage the experience and length of tenure of quality caregivers as an asset.
5. Convene regular staff meetings with caregivers and curators to enhance communication and exchange information.

6. Set protocols and policies for the safety of gorillas and caregivers.

7. Allot a portion of the keeper's day for observation of gorilla behavior.

8. Encourage time spent fostering and maintaining a caregiver's relationship with the gorillas.

9. Send caregivers with gorillas during long-distance transfers. The animals' health and safety can be monitored throughout the duration of the trip. This also reduces stress and helps them to adjust to their new surroundings and keepers.

10. Avoid hasty decisions and allow sufficient time for daily routines. Expediency should be secondary to the needs of the gorillas in all things.

11. Provide the gorillas as much free choice as possible.

12. Keep detailed, daily records on individual gorillas and their groups. Use these records as part of a keeper training program.

13. Design an enrichment program to provide a stimulating environment for the gorillas and update it periodically.

14. Whenever possible, as with any species, integrate keeper staff into the decision making process with regard to the gorillas, including enrichment, enclosure design, diet, and introductions. This process ideally should include input from keepers, curators, veterinarians, and research staff.
IMPLEMENTATION OF POSITIVE REINFORCEMENT TRAINING

S. Snowden, M. Sevenich

Gorilla caregivers in zoos around the country are recognizing the value of positive reinforcement training as a way to aid in daily gorilla husbandry, solve behavioral and social problems, and provide positive enrichment for both gorillas and keepers. This chapter presents an overview of the collected expertise and experiences of these institutions. Its goal is to define positive reinforcement training, discuss how it can be applied, and create a gorilla training network for anyone currently involved in training or anyone wanting to start a program.

POSITIVE AND NEGATIVE REINFORCEMENT

Positive reinforcement and negative reinforcement are two of the most commonly used training techniques. With both techniques, an animal can modify its behavior to earn a reward or avoid an aversive stimulus. Both techniques can successfully modify and increase the frequency of behavior. What is positive reinforcement? "Positive reinforcement is anything which, occurring in conjunction with an act, tends to increase the probability that the act will occur again" (Pryor, 1984). In other words, positive reinforcement is something the subject wants and will work to obtain. "Negative reinforcement is something the subject will work to avoid" (Pryor, 1984). Negative reinforcement, however, is different from punishment. "Punishment comes after the behavior it is meant to affect. Thus, you can't avoid receiving a punishment by changing your mind, or your actions, since the misbehavior had already happened" (Pryor, 1984). Punishment is meant to "teach the subject a lesson," but it is delivered too late to have much impact on future behavior.

A good rule of thumb for differentiating between the two techniques is remembering that both are common in the lives of humans and wild animals. Humans work to avoid hearing the alarm in the morning, for example, or the buzzer that indicates an undone seat belt. Conversely, opening the refrigerator is an act that brings a reward. In the wild, animals return to a successful foraging spot day after day, yet they work to avoid unpleasant experiences like contact with prickly bushes.

Although negative reinforcement is a useful tool, and in some cases may achieve the desired result more quickly than positive reinforcement, it can be difficult to regulate and implement. Animals may become desensitized to the negative stimulus, which requires increasing the intensity of a stimulus to achieve the same result. The animal may also associate the negative stimulus with the person delivering the stimulus, which can harm the caregiver's rapport with the animal. In some cases, negative and positive reinforcement can be used simultaneously. Once the behavior is learned, the negative stimulus can be gradually faded, leaving only the positive reinforcement to maintain the behavior.

Through our experiences and those of others, we have seen that positive reinforcement is
effective in changing behavior while cultivating a beneficial relationship between the animal and caregiver. Because positive reinforcement has so successfully modified behavior, it is the method we recommend.

GETTING STARTED

Reading training literature--a good way to start a program--will aid in your understanding of conditioning theory and allow you to learn from the experiences of others. The most useful resource for many trainers has been Don't Shoot the Dog! (Pryor, 1984). Also, the titles in the reading list following this chapter provide additional information. Here are some important, helpful tips to include in a training program.

START WITH A CLEAR PLAN

A program is headed for success if the staff can agree on what the problem is and how it should be handled. During the initial meeting, ask these four questions:

1. Where are we now? (current behavior)
2. Where do we want to go? (behavioral goal)
3. How do we want to get there? (training program)
4. What role will each person play?

It is important to review the behavior of the staff, as well as that of the animal. In many cases, inconsistencies in an animal's behavior are due to an inconsistent training approach by the staff. Understanding and taking responsibility for an animal's behavior is an important lesson. It is easy to forget that, like it or not, we helped create the behavior we see.

After the group has agreed on the behavior to be trained, identify what steps lead to the goal. Outlining the steps in writing can provide a valuable visual aid for tracking progress. Assign roles to everyone involved. Then pick one caregiver to work with the animal throughout a behavior learning process. The reason for this is that the learning process requires clear, intense communication between the animal and trainer. It is very difficult for different trainers to be consistent, so multiple "teachers" tend to confuse the animal.

While the animal is learning, it is important that only one person train that specific behavior. It does not, however, seem to be too confusing to have other trainers teach different behaviors to the same animal concurrently. After a behavior is trained, other staff members can learn how to ask for and maintain it.

If possible, begin working with what is perceived to be the easiest animal and/or behavior to train. This can help develop a trainer's technique and confidence. Programs involving many animals of the same species and multiple trainers may benefit from an initial pilot study. The information gathered in a pilot study involving fewer animals and trainers may help you develop
a more organized, effective long-term program.

**KEEP RECORDS OF YOUR TRAINING SESSIONS TO TRACK PROGRESS**

Records are also useful when you are trying to teach the behavior to a different animal. If an animal stops performing a behavior, the records can aid another trainer in the retraining process.

The timing of the delivery of reinforcement is crucial. It must immediately follow the desired behavior in order for the animal to make a connection between the behavior and the reinforcement. Once the animal makes this connection, however, it will repeatedly display the behavior in order to earn additional reinforcement. If the reinforcement is delivered too late, the animal may associate it with a behavior other than the one the trainer was trying to reinforce.

Because it is not always possible to deliver a food or tactile reward immediately following the desired behavior, a "bridge"--which may also be called a "secondary reinforcer" or "conditioned reinforcer"--is used to bridge the gap between the behavior and the actual reward. If your program requires conditioning the animal to a bridge, it is easier if the staff is consistent. Choose a word, a dog whistle, a clicker, or any stimulus that can be perceived easily by the animal. Keep in mind that each bridge has its own advantage. A whistle is very distinct. Your voice is handier than a whistle. A clicker is distinct but may tie up one of your hands. Select a bridge that works best for your training team. Training is flexible; if you are unhappy with your bridge, try something new.

The question of how to motivate an animal to participate comes up at the beginning of every training program. Motivation should be evaluated on an individual basis. Food is a popular device. According to the Gorilla Husbandry Survey (Appendix A), of 39 institutions 32 of them (82 percent) use food as reinforcement to transfer or switch gorillas. On some occasions, additional food or substitutions of more desirable items may increase an animal's attention span. Some gorillas accept nonfood reinforcements, such as back scratches.

**SESSIONS SHOULD NOT EXCEED THE ATTENTION SPAN OF THE STUDENT**

After a few sessions, you will know how long the animal will remain reasonably attentive. Many trainers spend too much training time requesting previously learned behaviors and saving new learning for the end of the session. Pushing to achieve too much progress at the end of the session, when the animal's motivation is lowest, can frustrate both gorilla and trainer. Balance the types of behaviors you request throughout a session and try to end your session on a positive note.

**TRAINING AIDS**

94
Using objects as training aids can be an effective, time-saving way to train an animal to hold a position at a station, to allow keepers access to a body part, or to encourage an animal to perform a specific motion. After training an animal to touch an object for a reinforcement, the trainer is then open to use this concept in several ways. Any object used to focus attention or lead an animal to a specific behavior is known as a "target." Targets can take on many forms and serve a variety of functions. Following are two examples of the many ways targets can be used.

A gorilla desensitized to accept a medical procedure is first trained to hold onto a target or take a station position. It is then trained to remain relaxed in the station position and accept the procedure. For example, a gorilla can be asked to hold metal clips on the cage front with its hands. In this position, additional targets are used to train the gorilla to present any body part to the keeper. In another case, moveable or stationary targets used as feeding stations can aid in separating animals. The target identifies where an animal should go and hold a position. This technique, which allows trainers to work with animals individually, can decrease food-related aggression between animals.

Some animals touch targets immediately out of curiosity. If an animal shows no interest or is shy, try smearing food on or near the target. If the animal seems frightened by the target, leaving it in view at a distance as an initial introduction can be helpful. Bringing the gorilla to the target instead of the target to the gorilla may help make it less intimidating.

**TYPES OF BEHAVIORS**

**ROUTINE BEHAVIORS**

These include any behaviors that make daily husbandry easier. Brookfield Zoo, Columbus Zoo, Toledo Zoo, National Zoo, Toronto Zoo, and Monkey Jungle have successfully taught a variety of physical commands, such as "target," "come here," "gentle/easy," "stand," "hold," "sit," "give," "shift/gate," and "retrieve" (see Table 1).

**MEDICAL BEHAVIORS**

According to the Gorilla Husbandry Survey, 26 (about two-thirds) of the 39 institutions that responded condition their gorillas to allow regular close inspection. Some zoos have trained specific behaviors that simplify veterinary care and obviate the use of anesthetics. Toledo Zoo, National Zoo, Toronto Zoo, and Monkey Jungle have taught their gorillas to open their mouths, show their hands and feet, allow tympanic temperature to be taken, and present various body parts for inspection. "King," the silverback at Monkey Jungle, tolerates a tongue depressor, nasal swabs, and having his heartbeat monitored by stethoscope (see Table 2).
Toledo Zoo, Toronto Zoo, and Monkey Jungle have all been successful at training gorillas to accept injections. Toledo Zoo has used this behavior to anesthetize animals but reports that the behavior is lost for a week or so following the procedure.

**MATERNAL CARE**

Choosing appropriate training goals to facilitate infant-rearing skills can be difficult. Because reasons for maternal failure vary between individuals or even with the same mother, it is sometimes hard to identify or anticipate behaviors needed prior to birth. Trained behaviors labeled as "maternal" do not necessarily enhance a female's ability to raise her own infant, but they may allow access to an infant for supplemental care (see Table 3).

Calgary Zoo is preparing a paper about its experience in using training to encourage a gorilla mother to feed and bond with her infant. Metro Toronto Zoo has done extensive training with one gorilla, "Josephine," whose infants are consistently hand-reared because she doesn't produce enough milk. Their goal is to teach "Josephine" to bottle feed and raise her own infant. The keepers have published a paper on their early efforts, and "Josephine's" training continues. The San Diego Zoo is currently training an older female, "Alvila," to hold a doll to the wire, in preparation for introducing a neonate that will require supplemental feedings.

Brookfield has had mixed results with the gorilla "Aquilina," who exhibits strong maternal behaviors but won't allow her infants to nurse. After pulling an infant for hand-rearing, keepers started training "Aquilina" to bring the infant to the cage front for a bottle. She responded well to training but would not take her baby back. Brookfield Zoo keepers also worked with "Binti," a hand-reared, six-year-old gorilla. They taught her to present her chest for nipple stimulation and to accept a breast pump (to simulate nursing), to correctly position a surrogate for nursing, and to position the surrogate at the cage front for a bottle. When "Binti" gave birth, she held her infant in a manner that was secretive and made nursing difficult to monitor. Only two nursing bouts were evident on the first day, so on the second morning, a keeper, after seeing that the infant was rooting, asked "Binti" to position her arm so that her breast was visible. The keeper saw the baby nurse successfully while "Binti" sat calmly. It was determined that she might be nervous about being constantly watched. After vigilance was relaxed, nursing bouts became more visible, frequent, and, finally, commonplace. Keepers at the Columbus Zoo have also been successful at getting a female to be a surrogate "mom" or "aunt" for a hand-reared infant and are training this female to bring the infant to the window for supplemental bottle feedings.

**INTRAGROUP RELATIONSHIPS**

Many of the routine behaviors discussed above have been used successfully at Toledo Zoo to facilitate introductions and promote social cooperation and tolerance. Food rewards and extra attention keep the focus away from other animals, helping to reduce aggressive interactions or diffuse ones that may occur.
REPRODUCTIVE STATUS

National Zoo and Woodland Park Zoo have conditioned female gorillas to give urine samples on request. In addition, Woodland Park Zoo has trained females to present for vaginal swabs, enabling keepers to chart menstruation, LH surge, sexual behavior, pregnancy, and parturition on cooperating female gorillas.

OVERCOMING FEAR

Gorillas can be uncooperative and hard to manage when they are frightened. In these cases, the event the animal fears can be paired with a reward. Eventually, the animal may desensitize to the event and overcome the fear. This technique is most successful if the adverse stimuli can be presented in small increments. Columbus Zoo used positive reinforcement training to help a female gorilla overcome her fear of an overhead exhibit access chute. Woodland Park Zoo is using timed introductions to ease an especially tense female into a new social group.

OTHER BENEFITS

GORILLA/KEEPER RELATIONSHIPS

Every zoo contacted commented on the benefit of a positive rapport between gorillas and keepers, and all felt that training contributed to that rapport. They felt that their gorillas enjoyed and looked forward to the training sessions and that some animals' attitudes toward their human caretakers improved because of the contact.

BEHAVIORAL ENRICHMENT

Many of the zoos mentioned "behavioral enrichment" as a reason for training. Studies with chimps have documented that training does serve as an effective form of enrichment, both during and following training sessions (Bloomsmith, 1992). Training adds variation to the animals' routines and provides a chance for extra food and attention. Even if enrichment isn't the primary reason to train, it is almost always a secondary benefit. Sometimes a lone, sedentary animal, besides enjoying the increased mental stimulation, also learns behaviors that get it up and moving around in its environment. Exercise then becomes another benefit of training.

CONCLUSIONS

Positive reinforcement training is an effective way to help solve behavior problems, provide enrichment, and enhance our relationships with the animals in our care. The information provided here should help a gorilla caregiver decide whether positive reinforcement training would be an asset to their husbandry program.
WHOM TO CONTACT

Brookfield Zoo
3300 Golf Rd.
Brookfield, IL 60513
Phone (708) 485-0263
Fax (708) 485-3532
Contact: Craig Demitros, Stephanie Snowden, Betty Green, Joanne Leveille
Coordinator of Animal Training and Behavioral Enrichment: Marty Sevenich

Calgary Zoo
P.O. Box 3036 Station B Calgary
Alberta, Canada T2M 4R8
Phone (403) 232-9356
Fax (403) 237-7582
Contact: Rob Sutherland

Columbus Zoo
P.O. Box 400
Powell, OH 43065
Phone (614) 645-3540
Fax (614) 645-3465
Contact: Charlene Jendry

Metropolitan Toronto Zoo
P.O. Box 280 West Hill
Ontario, Canada M1E 4R5
Phone (416) 392-5901
Fax (416) 392-5934
Contact: Luisa Steinsky (seals and camels), Vanessa Phelan (Africa Pavilion/gorillas), Dianne Revison (area supervisor, Africa Pavilion/gorillas)

Monkey Jungle
14805 S.W. 216A
Miami, FL 33170
Phone (305) 238-9981
Fax (305) 235-4253
Contact: Sian Evans, Sharon Dumond, Julio Perla, Tina Casquerili

National Zoo
3000 Connecticut Ave. N.W.
Washington, D.C. 20008-2598
Phone (202) 673-4875 -- Rob and Melanie
Phone (202) 673-4888 -- Lisa
Fax (202) 673-4888
Contact: Rob Shumaker, Melanie Bond, Lisa Stevens
North Carolina Zoological Park
4401 Zoo Parkway  
Asheboro, NC 27203  
Phone (910) 879-7672  
Fax (910) 879-2891  
Contact: Debbie Mounts, Lucy Seegerson, Cathie Grant  
c/o African Pavilion

Toledo Zoological Society  
2700 Broadway, Box 4010  
Toledo, OH 43609  
Phone (419) 385-5721  
Fax (419) 385-6935  
Contact: Char Petiniot, Robin Wright, Carol Rexer, Andrea Steedle, Mike Dily

Woodland Park Zoo  
5500 Phinney Ave. N.  
Seattle, Washington 98103  
Phone (206) 684-4811  
Fax (206) 684-4854  
Contact: Violet Sunde, Judy Sievert, Helen Shewman, Mary Keiter

ACKNOWLEDGMENTS

Much of the information in this chapter was obtained from an independent survey the authors sent to zoos that we knew had active gorilla training programs. We'd like to thank them for the time and effort they put into the surveys--we had an 82 percent return rate! Because we had to work by word of mouth, we may have overlooked some institutions. If we inadvertently left out your program, we apologize.

SUGGESTED READING LIST

In addition to the following materials, check current AZA, AAZK, IMATA, and IAATE conference proceedings for articles and training projects.

Training Technique


For additional training books and videos by Karen Prior and Gary Wilks, contact Sunshine Books, 44811 SE 166th St., North Bend, WA 98045.

Setting Up Training Programs


**Primate-Specific Training Programs/Uses for Training**


Increasing attention is being paid to the subject of enriching the environments of captive animals. Environmental enrichment is, of course, mandated for captive primates by the animal welfare regulations, because it contributes to the psychological well-being of these animals. The effectiveness of this work has received substantial study, which has helped to evaluate different forms of enrichment.

Environmental enrichment for gorillas covers a wide variety of topics, which can be broken down into two broad categories: 1) social--relationship with other gorillas, relationship with caretakers; and 2) physical--living space, diet, browse, substrate, manipulable nonfood objects. All of the physical forms of enrichment, except for living space, can be considered exhibit additives.

While social groupings, living space, diet, and relationship with caretakers are all vital components of environmental enrichment for gorillas, each of these is being addressed under separate headings within this manual. This chapter will be limited to a discussion of browse, substrate (in the context of feeding enrichment and bedding), and manipulable nonfood objects.

The term "environmental enrichment" is frequently used to describe any number of husbandry practices. However, enrichment should be measured by the species for which it is being provided. What is enriching for an orangutan may be meaningless for a gorilla. Evaluation of the effectiveness of environmental enrichment (i.e., effect on psychological well-being) is a very complex task. Several general measures of psychological well-being are often suggested, including an increase in species-typical behaviors, an increase in activity levels, a decrease in abnormal or undesirable behaviors, and an increase in behavioral competence (e.g., Markowitz and Woodworth, 1978; Novak and Suomi, 1988; Novak and Drewson, 1989). These measures have their advantages and disadvantages, yet they provide a basis for simple evaluation. Enrichment, theoretically, increases activity, mental stimulation, and species-typical desirable behaviors, and promotes behavioral competence.

Environmental enrichment is truly effective when it increases the choices available for individuals (Shumaker, 1989) and includes diversity and change. The amount of choice that an individual animal is able to exercise over its environment, both social and physical, is directly proportional to the sense of control it perceives hourly, daily, yearly, or for a lifetime. Individuals that possess a sense of control based on positive, species-typical activities are more behaviorally competent than those that do not (Markowitz, 1982; Novak and Suomi, 1988; Novak and Drewson, 1989). In a social setting, enrichment is a powerful force to give each member of a group the maximum amount of choice, and therefore control, possible. Appropriate enrichment techniques can serve as the social catalyst that promotes positive and constructive interactions between individuals.
There have been numerous studies focusing on the feeding behavior of primates. For the majority of primates, there is general agreement that allotting a significant portion of a day's activities to foraging and feeding is healthy and important. Browse, variety in the daily diet, and novel presentation of foods are all effective ways to stimulate normal feeding patterns.

Browse refers to any sort of plant or plant part that is fed whole. For example, tree limbs, bush branches, flowers, herbs, whole plants--such as bamboo or cornstalks--and similar items would be categorized as browse. Nearly 100 percent of the Gorilla Husbandry Survey respondents utilize browse as enrichment (frequency of presentation was not available).

The most important thing to consider about browse is its potential toxicity. Obviously, any browse plants should be naturally nontoxic. Additionally, it should be known whether or not the browse has ever been sprayed with insecticide or other chemicals. The environment that the browse has been taken from should also be considered. For example, is the tree that is being pruned regularly exposed to heavy automotive emissions? (See attached: the National Zoo's approved browse list as an East Coast sample.) Additionally, the presence of thorns or other physical characteristics that may lead to health issues need to be considered. Further, some nontoxic compounds may be problematic (e.g., lignin: Ensley, 1982).

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

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

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

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

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

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

FORAGE MATERIALS

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

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

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

The following forage foods have been used successfully with gorillas at the National Zoological Park:

- breakfast cereals (Shredded Wheat, puffed rice, puffed wheat, puffed corn)
- prepared herbivore pellets, alfalfa pellets, dry dog kibble, flamingo pellets
- bird of paradise pellets
- low-oil sunflower seeds*
- air-popped popcorn
- raw, shelled peanuts*
- dried fruit*
- uncooked rice (brown and white)
- scratch feed
- nuts in the shell*
* These items are higher in fat and/or calories and should be used in moderation.

While certainly not exhaustive, this list suggests food that the animal care, veterinary,
and dietary management staffs have all agreed are appropriate. Most importantly, they are also palatable to and popular with the gorillas.

**NOVEL PRESENTATION OF FOODS**

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

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

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

**VARIETY OF FOOD PRESENTED**

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

Another possibility is to establish a list of equivalent foods that can be used to meet
similar requirements in the daily diet. For example, almost every zoo feeds some citrus food to their gorillas. Instead of using oranges daily, rotate lemons, limes, grapefruits, or tangerines in their place. The same is true for leafy greens and other standard foods. The important point is that the same foods should not be given day after day without any variation. A slight change in the diet each day, or even every other day, is a powerful way to stimulate interest and investigation. [It should be noted that many common fruits are high in calories and should be used in moderation. Although wild lowland gorillas have been observed to commonly feed on fruits, these fruits are generally less sweet and lower in calories than typical commercially available fruits (Edwards, pers. comm., 1996).]

**NONFEEDING ENRICHMENT**

Although zoo animals used to be housed in fairly hard, sterile environments, this philosophy has changed significantly during the past two decades. More commonly, living areas have soft, flexible substrates of grass, soil, or a number of other appropriate options. Nearly 90 percent of the respondents to the Gorilla Husbandry Survey use soil or grass in their gorilla living spaces.

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

We can assume that if time and energy are committed to an activity in the wild on a regular basis, it must be an important activity and should be allowed to occur in captivity. While not all individuals will use bedding materials, those that do not may only need the opportunity to learn how. Gorillas make and use nests on a daily basis in the wild; therefore, it seems an important aspect to provide in a captive environment. Many individuals, especially the very young, the old, or pregnant females, have a special need for comfort while resting.

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

In addition, the appearance of enclosures produces very real conscious and subconscious impressions to the visiting public. Zoo visitors generally form their ideas about standards of care and enrichment from an initial visual impression of enclosures and the behavior of the animals within them. The presence of a soft substrate immediately affects what the visitor sees; the image of the enclosure is softened and more appealing. The environment looks much more complex and comfortable. Every zoo tries to communicate effectively with its visitors, and every effort is made to educate and express our concern about the animals being cared for. However, these means are not nearly as effective as the appearance of the space where the animals spend their
There can be little doubt that the image of a gorilla sleeping in a nest of hay creates a very different impression for the visitor than seeing a gorilla lying on a hard, bare floor.

**OBJECTS FOR MANIPULATION**

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

Some zoos may have exhibit philosophies that preclude the use of items that do not appear naturalistic. In those cases, compiling a list of items that caretakers can provide may be more difficult, but not necessarily more limited. Providing gorillas with nonfood objects that can be manipulated is perhaps the biggest challenge to any caretaker's creativity, especially because some enrichment items may be quickly destroyed. Yet a gorilla's tendency to be destructive to objects in an environment is another piece of the species-typical behavior patterns that we are trying to encourage, so manipulable objects should be given with the intention of letting them be destroyed.

The list of objects that can be given is endless. Something as simple as an empty cardboard box can be a huge treat, and will often be gone in under an hour. Plastic 55-gallon juice-concentrate drums are incredibly durable and very popular. Natural objects such as plants, trees, logs, bark, moving water, and sticks can also provide manipulable objects for gorillas. Whether "natural" or "unnatural," the presence of manipulable items in the gorillas' on-exhibit living space presents an important message to visitors about the efforts caretakers are making to provide an enriched environment for the gorillas.

The numerous studies on environmental enrichment have confirmed what all animal caretakers already know: that there are many individual differences regarding preference for environmental enrichment items (Bloomsmith, 1989). What excites one individual may bore another completely. Levels of interest in particular forms or items of enrichment may be influenced by gender, age, social position in the hierarchy, and individual history. Trial and error, creativity, and persistence in presentation of novel (and sometimes ignored) forms of enrichment are all necessary for success. The point of environmental enrichment is to provide the animals with as much control over their environment as possible, and the best way to provide control is to have options at your disposal. Individually, substrates, browse, forage foods, social opportunities, objects, etc. are all good, but they are only pieces in the puzzle. Taken together, options and choices in all of these areas provide a more complete mental and physical environment for gorillas.
Alder (*Alnus spp.*)
Amaranth (*Amaranthus spp.*)
Amelanchier or shadbush (*Amelanchier spp.*)
Apple (*Malus spp.*)
Arborvitae (*Thuja spp.*)
Aspen (*Populus spp.*)
Beech (*Fagus spp.*) -- only in spring
Birch (*Betula spp.*) -- only in spring
Blackberry (*Rubus spp.*)
Bush Honeysuckle (*Lonicera spp.*)
Cattails (*Typha spp.*)
Comfrey (*Symphytum spp.*)
Cotoneaster (*Cotoneaster spp.*) -- in winter
Cottonwood (*Populus spp.*)
Daylily (*Hemerocallis spp.*)
Dogwood (*Cornus florida*)
Elaeagnus (*Elaeagnus spp.*)
Elm (*Ulmus spp.*)
Fig (*Ficus spp.*)
Grass family (*Graminae*)
Greenbrier (*Smilax spp.*)
Hackberry (*Celtis spp.*)
Hawthorn (*Crataegus spp.*)
Hazelnut (*Corylus spp.*)
Hibiscus (*Hibiscus spp.*)
Japanese silver grass (*Miscanthus spp.*)
Kerria (*Kerria spp.*)
Kudzu (*Pueraria spp.*)
Linden (*Tilia spp.*)
Maple (*Acer spp.*), including box elder, excluding red maple
Mock orange (*Philadelphus spp.*)
Mulberry (*Morus spp.*)
Nasturtium (*Nasturtium spp.*)
Pear (*Pyrus spp.*)
Poplar (*Populus spp.*)
Raspberry (*Rubus spp.*)
Redbud (*Cercis canadensis*)
Rose (*Rosa spp.*)
Snowberry (*Symphoricarpos spp.*)
Sweetgum (*Liquidambar*)
Willow (*Salix spp.*)
Columbus Zoo Approved Browse Species List

Acacia
Alfalfa (*Medicago sativa*)
Alder (*Alnus spp.*)
Amaranth (*Amaranthus spp.*)
American Beech (*Fagus grandifolia*)
Apple (*Malus spp.*)
Apple leaf croton (*Codiaeum cadierei*)
Aralia (*Polyscias balfouriana marginai*)
Arbovitae (*Thuja spp.*)
Areca palm (*Crysalidocarpus lutescens*)
Artillery plant (*Pilea microphylla*)
Aspen (*Populus spp.*)
Banana (*Musa acuminata*)
Bamboo (*Arundinaria spp., Phyllostachys spp., Semiarundinaria spp., Sinarundinaria spp.*)
Bamboo palm (*Chanaedorea erumpens*)
Black locust (*Robinia pseudoacacia*)
Black willow (*Salix nigra*)
Bottle palm (*Beaucarnea recurvata*)
Bush honeysuckle (*Lonicera spp.*)
Butterfly bush (*Buddleia spp.*)
Carob
Cattails (*Typha spp.*)
Chicory (*Cichorium intybus*)
Clover (*Trifolium spp.*)
Coffee plant (*Coffea arabica*)
Comfrey (*Symphytum spp.*)
Coleus (*Coleus spp.*)
Corn plant (*Dracaena fragrans massangeana*)
Cottonwood (*Populus spp.*)
Crabapple (*Malus spp.*)
Croton (*Codiaeum spp.*)
Daylily (*Hemerocallis spp.*)
Dracaena (*Dracaena ssp.*)
Dragon tree (*Dracaena draco*)
Dwarf palm (*Chamaedorea elegans*)
Dwarf rose (*Cryptanthus roseus pictus*)
Elaeagnus (*Elaeagnus spp.*)
Elm (*Ulmus spp.*)
Eucalyptus
Eugenia
Flowering dogwood (*Cornus florida*)
Forsythia (*Forsythia spp.*)
Fragrant honeysuckle (*Viburnum spp.*)
Grape (*Vitis vinifera*)
Greenbriers (*Smilax spp.*)
Gloxinia (*Sinningia* spp.)
Hackberry (*Celtis occidentalis*)
Hazelnut (*Corylus* spp.)
Hawthorn (*Crataegus* spp.)
Hibiscus (*Hibiscus rosa*)
Hickory
Jade plant (*Crassula argentea*)
Kentucky coffee tree (*Gymnocladus dioicus*)
Kerria (*Kerria* spp.)
Kudzu (*Pueraria* spp.)
Lady palm (*Rhapis excelsa*)
Maple (*Acer* spp.)
Mesquite
Mock orange (*Philadelphus* spp.)
Mulberry (*Morus* spp.)
Nasturtium (*Nasturtium* spp.)
Oak
Oregon grape holly (*Mahonia* spp.)
Pear (*Pyrus* spp.)
Peperomia (*Peperomia* spp.)
Pickerelweed (*Pontederia cordata*)
Pine
Poplar (*Populus* spp.)
Primula (*Primrose* spp.)
Privet
Purslane (*Portulaca oleracea*)
Raspberry, Blackberry (*Rubus* spp.)
Redbud (*Cercis canadensis*)
Red tip
Rose (*Rosa* spp.)
Saltbush
Snowberry (*Symphoricarpos* spp.)
Sweetflag (*Acorus calamus*)
Sweetgum (*Liquidambar styraciflua*)
Violet (*Viola* spp.)
Water hyacinth (*Eichhornia* spp.)
Wax myrtle
Weeping fig (*Ficus benjamina*)
Willow (*Salix* spp.)
BIRTH MANAGEMENT AND HAND-REARING OF CAPTIVE GORILLAS

THE SOCIAL DEVELOPMENT OF INFANT GORILLAS IN THE WILD

To fulfill the social needs of an infant that requires hand-raising, the captive manager must understand the type of social environment in which a wild infant is born and raised. Information on the behavior of wild gorillas is derived from the long-term, field research of the subspecies Gorilla gorilla beringei. Comparable data for G.g. gorilla, the subspecies primarily found in captivity, are not available. Harcourt (1987) suggests that the subspecific differences are unimportant in the context of using those data to improve captive management practices. Gorilla infants are born into mixed age/sex groups ranging in size from 4 to 30 (Harcourt, 1987), with 10 (west side) and 5 (east side) the median group sizes for the gorillas of the Virunga study site (Harcourt, 1979). Sixty percent of the groups contain 1 silverback, 40 percent more than 1 (Harcourt, 1987).

For the first three to five months of its life, an infant is in continual contact with its mother (Fossey, 1979; Harcourt, 1987). At four months, the infant begins to venture off the mother, but stays within arm's length. Social interactions with conspecifics are carried out within the safety of the mother's presence. Play with similar-aged youngsters increases greatly between the ages of 6 to 12 months, but not until the second year does social play exceed the frequency of solitary play (Fossey, 1979).

Mothers with young infants spend more time in proximity to the silverback than other females (Harcourt, 1987). Into their second year, infants begin to manifest a great interest in the silverback and actively maintain close proximity to him (Stewart and Harcourt, 1987). While growing up in its group, the infant gorilla learns adult roles and social behavior. For example, the infants learn that the silverback is the leader of the group. Agonistic interactions that occur between group members may be terminated by the silverback through subtle gestures, such as a look, a belch vocalization, or, more overtly, a rush and hit. More aggressive displays are directed toward peripheral males and maturing blackbacks in the group who begin to challenge the silverback's status. However, the silverback's interactions with youngsters are primarily affiliative, expressed through grooming or maintaining close proximity. Indeed, the silverback is a role model of tolerance when infants and juveniles play near or even on him. Sexual behavior is observed by youngsters, who between two and three years old begin to show an interest in copulating adults. Juveniles of both sexes and young adult females show the greatest interest in mothers with newborns.

EFFECTS OF HAND-REARING

Hand-rearing is a term that encompasses a wide continuum of methods. At one extreme is
the infant that is totally isolated from conspecifics, given a minimum of attention by its caretakers, and resocialized at a late age. At the other extreme is an infant that is hand-reared in the presence of conspecifics, provided extensive human and environmental stimulation, socialized at a young age with peers, and integrated into a mixed age/sex social group at a young age. An accurate assessment of the effects of hand-rearing should distinguish among the different methods used.

The success of a hand-rearing program has typically been measured in terms of reproductive success: whether the hand-reared individual could reproduce and, in the case of a female, could raise her infant. These criteria, easily measured, are indeed important. However, complete success should be defined as the individual exhibiting species-typical behavior in appropriate contexts. Today, captive breeding programs must strive to maintain the full behavioral complexity of a species. Just as we develop breeding programs to maximize genetic diversity, so should we develop management programs that maximize retention of the full repertoire of behavior patterns and intellectual flexibility inherent in a species.

Harlow's research (e.g., Harlow, 1962; Harlow and Harlow, 1965; Harlow and Lauersdorf, 1974) demonstrated the effects of the extreme end of hand-rearing. The male's ability to mount and copulate and the female's ability to present and stand for the male was severely and negatively affected when infant rhesus macaques were raised in isolation from their mother and peers. "Motherless mothers" ignored or abused their infants. All youngsters raised in isolation exhibited one or more stereotypic behaviors that later in life interfered with their social interactions. The age at which infants were separated from their mothers and the duration of social isolation affected the severity of the disturbances displayed by the macaques.

Zoo populations are not set up as experimental groups. Thus, the selection of categories for analysis may need to be fairly broad. For example, Beck and Power (1988) lumped together all hand-reared gorillas in the North American population to compare their reproductive success to captive-born, mother-reared individuals. Despite not distinguishing hand-rearing methods, the authors did find that mother-reared females were significantly more likely to mate and conceive than hand-reared females.

Differentiating hand-reared females that did and did not have social access to a conspecific(s) within the first year of life revealed that those with first-year access were significantly more likely to conceive. A comparison of hand-reared versus mother-reared males showed no significant difference in reproductive success; however, the sample size (17) was small (Beck and Power, 1988). An expanded analysis encompassing the entire captive population was carried out by Meder (1989). The difference in the reproductive success of mother-reared (87 percent) versus hand-reared (57 percent) females remained significant. With a greater sample size, a significant difference was also found in the number of mother-reared males who successfully reproduced (69 percent) as compared to hand-reared males (27 percent). Although not statistically significant, a higher percentage of hand-reared (39 percent) versus mother-reared females (27 percent) rejected their infants.

Comparative data on the behavior of adult hand- versus mother-reared gorillas are limited. Gould and Bres (1986) found that the abnormal regurgitation and reingestion habit occurred more frequently in hand- versus parent-raised gorillas. The consequences are far
reaching, because not only does this habit affect the health and educational/display value of the individual, other members of the group can observe and learn to perform the behavior (Porton, pers. obs.). Observations on the social interactions of five males in an all-male group (Porton, unpublished data) reveals a marked difference in the behavior of hand- versus parent-reared males. The two parent-reared males are socially more competent as defined by greater frequencies of affiliative social interactions, social proximity scores, and the number of individuals with whom they interact. An especially pronounced contrast is the interest and lack of fear the two parent-reared males exhibit toward the eldest male in the group.

**BEHAVIORAL COMPARISONS OF HAND- VERSUS MOTHER-REARED YOUNG**

Several studies have compared the difference in the behaviors of hand- versus mother-reared youngsters. Gold (1992) observed 12 mother-reared and 8 hand-reared gorillas at 10 North American institutions. Data were taken for eight nonsocial behaviors: self-directed behavior, object contact, locomotion, solitary behavior, rest, environmental exploration, mouthing, and displaying. The percent frequency of resting and environmental exploration was significantly higher in mother-reared young; the percent frequency of self-directed behavior and displaying was significantly higher in hand-reared young. Displaying by young hand-reared gorillas was also observed in inappropriate contexts, such as toward adults housed next to the youngsters.

Meder (1989) compared the solitary and social behavior of 7 mother-reared and 19 hand-reared infants and juveniles at 6 European institutions. She found that almost all the hand-reared but none of the mother-reared young exhibited abnormal behavior (digit sucking, rocking, etc.). Hand-reared young engaged in significantly more self-motion play, object play, locomotor, and aggressive (display) behaviors.

Both studies show that hand-reared youngsters self-stimulate (self-directed behavior, self-motion play, object play) more than mother-reared young. Of particular interest is that both studies found hand-reared young displayed more than their mother-reared counterparts. Such behavior has the potential to adversely affect the process of resocialization and, if/when integration occurs, the social harmony within a group.

**METHODS TO IMPROVE MATERNAL CARE**

Hand-rearing can detrimentally affect the intellectual, behavioral, and social development of a nonhuman primate, including the gorilla. Therefore, the Gorilla SSP strongly recommends that all institutions develop management programs that increase the likelihood infants will be mother-reared within a social group.

The Gorilla SSP recommends that each institution that houses a breeding group evaluate, as accurately as possible, the potential of mother-rearing within its group. If certain individuals are assessed as potentially problematic, it is suggested that a management strategy designed to increase the maternal potential of problem females be developed.
One management strategy is to incorporate the at-risk female into a breeding group in which she can observe other mothers raising their infants. Meder (1989) analyzed data comparing hand-reared females who did and did not have the opportunity to observe maternal care prior to giving birth to their own infants. Females with this observational opportunity were significantly more successful in rearing their own young (77 percent versus 38 percent).

Research with chimpanzees (Hannah and Brotman, 1990) revealed a similar result. Ten pregnant, hand-reared, maternally inexperienced chimpanzees were housed with lactating females and their offspring and/or infants. A control group of nine females were not exposed to mothers and/or infants. The authors found that 9 of the 10 females in the experimental group and none of the females in the control group were able to rear their young.

These data lead to several management strategies that an institution could develop with the assistance of the Gorilla SSP:

1. Think ahead! If the opportunity is available, resocialize a hand-reared infant female gorilla into a breeding group where she will have the opportunity to observe mother-rearing as she grows up.

2. Allow a maternally competent female in the social group to breed and raise her infant prior to breeding the maternally incompetent female.

3. Integrate a maternally competent female into the social group and follow Step #2.

4. Move the maternally incompetent female to another social group that includes competent mothers.

An innovative but more uncertain approach is to develop a training program that is designed to teach a female certain maternal skills. Such a program generally entails training the female to respond to a series of commands that will increase the likelihood that she will hold, carry, and/or nurse her infant. It is, of course, difficult to accurately measure the success of a training program because so many variables cannot be controlled. Joines (1977) trained a female gorilla to gently handle a doll and raise it to her breast; the female successfully raised her next infant. Another training program involving a gorilla (Schildkraut, 1982) was not successful. If being considered, such a program would benefit from the input of a professional animal trainer working closely with the keeper staff to develop a plan that is consistent and based on positive reinforcement and shaping techniques. Females that have shown a range of appropriate maternal behaviors but have failed to raise an infant due to an identifiable behavioral deficiency may prove to be good candidates for a training program. This approach could be used in tandem with the management strategies discussed above. Such programs can also be initiated to train females to bring infants to keepers for supplemental feedings.
Following a birth, close monitoring of the mother and infant is vital and should be conducted by staff members familiar with gorilla behavior and the behavior of the particular female. In the past, infants were often removed from their mothers within a day if there was no nursing or if awkward maternal behavior was observed. Competent maternal care improves with practice. It is therefore incumbent on the staff to carefully evaluate the mother/infant relationship, judge whether the mother's treatment of the infant endangers its health, and then decide whether the infant should remain with its mother or be removed from her.

Results from the Gorilla Husbandry Survey (data from 39 institutions) showed 11 infants died of maternal neglect/incompetence, 9 within the first 10 days of life. Six infants were reported to have died from maternal abuse, four within the first day. None of the responding institutions had ever lost an infant due to abuse from other females or related/unrelated males in the natal group. The reasons institutions gave for hand-rearing gorillas in their collection were: infant rejected by mother (13 zoos), maternal abuse (8 zoos), infant health problem (8 zoos), institutional policy (8 zoos), failure of infant to nurse (7 zoos), insufficient milk supply (3 zoos), maternal health problem (1 zoo). Some of the infants may have been pulled before a full evaluation of the mother/infant relationship was made.

The Lincoln Park Zoo (Rosenthal, 1987) has developed a 72-hour, post-partum observation protocol for gorillas based on their experience that infants can be pulled and successfully hand-raised after 72 hours of not nursing. The protocol lists four aspects that should be checked immediately after a birth:

1. The ability of the infant to cling to its mother. Fossey (1979) reports that a one-day-old infant is capable of clinging, unsupported, for three minutes.

2. The presence of mucus and placental membranes that could obstruct the mouth and/or nose of the infant.

3. The care the mother provides the infant. Has she cleaned the infant? Does she keep the infant with her, and in what position does she carry the infant? Is she protective of the infant?

4. Whether the placenta has been passed. Some, but not all females, eat the placenta. If the umbilicus remains attached to the infant, it should dry and detach by the third day.

Another useful guide was the continuum developed by Rogers and Davenport (1970) to evaluate maternal behavior in chimpanzee mothers in the first 12 hours post-partum. This guide, representing a continuum from negative to positive maternal care where 0=negative and 4=positive, can easily be used to evaluate gorilla maternal behavior. Obviously, if a female is abusing her infant, it should be removed right away. It should be noted, however, that "odd" behavior, such as placing an infant dorsally, is not inherently abusive and needs to be evaluated in a broader context.

0 No observed contact between mother and infant, with the mother ignoring or actively avoiding the infant.
The mother occasionally inspects and/or pokes at the infant but there is no prolonged contact or holding.

Infant in contact with the mother some of the time but is carried inappropriately (upside down or in one hand).

Mother carries infant constantly but at times is inattentive to it.

Mother carries the infant on the ventral surface, allows the infant to grasp, and responds to the infant's vocalizations by readjusting, examining, or clasping it.

Of course, the caretaking staff should carefully observe the mother/infant pair to determine if nursing is taking place. Experience at Lincoln Park shows that some infants may nurse as soon as 90 minutes post-partum, while some females may not even begin lactation until 24 hours post-partum. Round-the-clock observations revealed that an infant born at the Toledo Zoo nursed for the first time at hour 23 (Petinoit et al., 1988).

The 72-hour waiting period allows managers to give the mother/infant pair time to adjust to one another and synchronize nursing patterns. This is particularly important for the primiparous female. Rogers and Davenport (1970) found that it was very rare to see a mother chimpanzee place her infant directly on a nipple. However, time with the infant enables the learning of behaviors that facilitate nursing. They report that chimpanzee mothers respond to their infants’ vocalizations by readjusting them, which increases the likelihood that the infant will come into contact with a nipple. Eventually, the mother learns that placing the infant onto her chest causes the infant to stop vocalizing and relieves tension in her breast.

Although an infant may be seen on or near the nipple, it can sometimes be difficult to confirm successful suckling. It is normal for the newborn to pass the dark, pasty meconium within the first 48 hours. Thereafter, passage of a mustard-yellow stool and urine is good evidence that the infant is nursing.

Some institutions have the capability of remote observations, thereby allowing the mother and infant more privacy. This method may be particularly useful for situations in which the female or other group members become nervous when observed. An additional benefit is that volunteers (i.e. "strangers" to the gorillas who may disturb the mother) could be used, increasing the amount of time the mother and infant could be observed.

**Alternatives to Hand-rearing**

If observations indicate that the infant gorilla is not nursing and human intervention is necessary, the following alternatives to hand-rearing should be considered.

1. If the mother is exhibiting aspects of maternal care but the infant has not been observed to nurse during the 72 hours, it may be appropriate to provide the mother and infant with more time to coordinate nursing behavior. Additional time could be obtained by removing the infant, rehydrating it, and returning it to its
mother. An example of this occurred at the St. Louis Zoo with a primiparous chimpanzee who exhibited maternal care towards her newborn but nursing was not observed. The infant was removed from the female on the morning of the fourth day. The infant was kept for 24 hours and fed Pedialyte, then diluted and finally full-strength Enfamil. He was returned to his mother, who immediately accepted him, but again, nursing was not observed for 36 hours. The infant was again removed, bottle fed for 24 hours, and returned to his mother. The next day, six nursing bouts were observed and the female went on to successfully raise her baby.

2. With a female that prevents an infant from nursing, it may be possible to sufficiently distract the mother to allow the infant to nurse. The prior development of a positive and flexible relationship with the female by one or more members of the caretaking staff would obviously be beneficial. Alternatively, anesthetizing the female to permit the infant to suckle may stimulate further nursing. Such a procedure may be particularly helpful if the female's breasts are very full and tender and milking will relieve her discomfort.

3. If the female gorilla exhibits acceptable to good maternal behavior but prevents the infant from adequately nursing or has insufficient milk, a supplemental feeding program may be possible. Such a program was successfully carried out at the Audubon Zoo (Thorpe, 1989). The mother of a two-month-old gorilla was actively preventing the infant from nursing a sufficient amount. Because the mother would bring the infant to the wire, and because she could be distracted by being slowly hand-fed, the staff was able to supplement the infant with a bottle. The infant was fed as many as five bottles a day and was weaned from the supplemental feedings at 18 months. This innovative method allowed the infant to be raised within her social group. A similar program was successful in supplementing an infant orangutan (Fontaine, 1979).

4. An alternative to hand-rearing is possible if a surrogate mother is available to adopt the infant. A lactating female would be ideal, but the timing of such occurrences is mostly chance. Communicating with the SSP and initiating a nation-wide search may improve chances. If a lactating surrogate is unavailable, a maternally competent female who would permit the infant to be bottle fed, as described above, should be considered.

HAND-REARING

If no alternatives to hand-rearing are possible, a program with the objective to resocialize the infant with other gorillas at as early an age as possible should be designed. A hand-rearing program can basically be divided into two parts: meeting the physical needs of the infant and meeting the psychological and social needs of the infant.

PHYSICAL NEEDS
Because of their similarity to humans, caring for the physical needs of infant apes has been greatly simplified. Human formulas, such as Enfamil and Similac, have been successfully used to hand-raise gorillas. Isomil, a soy-based formula, can be used if the infant is allergic to milk protein or lactose, or Lactaid can be added to the formula. An array of human baby bottles with a variety of nipples, including those designed for preemies, have worked well when hand-rearing apes. The availability of neonatologists, experienced in crisis care of human infants, can be invaluable when an infant ape takes ill.

The amount of formula fed should be calculated on the basis of body weight. Infants must be weighed every day to monitor their progress and to adjust the amount of formula offered. In great apes and humans, the amount of formula offered should equal 20 to 25 percent of the infant's body weight per day. Ideally, the feedings should be spread over a 24-hour period at 2.5 to 3 hours apart. The dilute concentration of ape and human milk clearly indicates that the normal nursing pattern is one of many bouts, separated by relatively short intervals (Short, 1984). Not all institutions are able to provide 24-hour care throughout the entire rearing period, but should try to adjust the schedules to at least allow continual care for the first two weeks. If a zoo cannot commit the staff to provide continual care for hand-reared infants, perhaps "regional nurseries" (Beck, 1988) should be considered. Thereafter, a schedule comprised of seven feedings divided evenly between 6 a.m. and 12 a.m. has been successful (St. Louis Zoo records).

The age at which infant gorillas acquire baby teeth varies with individuals--incisor 1: week 6 to 13; incisor 2: week 7 to 20; premolar 1: week 16 to 29; premolar 2: week 40 to 54; canine: week 40 to 64 (n=6 infants; Holtkotter and Scharpt, 1992, St. Louis records). In the wild, infants begin to play with food items at 4 to 6 months of age, but more serious efforts to obtain and prepare solid food does not begin until the second year of life (Fossey, 1979). It is thought that infants are not nutritionally independent from their mothers until 18 to 24 months, but will continue to suckle until they are 3 years old (Stewart, 1992).

The age at which to begin offering solids to hand-reared infants does not need to occur earlier than what would be normal in the wild. Introducing a variety of food items at 4 months will permit the infant to play/experiment with the taste and texture of different foods while still obtaining its nutritional requirements from the formula. For humans and chimpanzees, it has been suggested that formula remain the basis of an infant's diet for 12 months. The addition of cereal to the formula is not necessary or advisable (Fritz and Fritz, 1985). Even when the infant is integrated into an adult group, it can be provided formula by its caretakers (training the infant to come to the mesh screening and accept a bottle or cup should be planned into the rearing program).

Nursery protocol must include accurate records containing the infant's weight, amount of food offered and consumed, stool consistency, body temperature, and overall health. Detailed accounting of the hand-rearing method, veterinary care, as well as the physical and behavioral development of the youngster should be recorded. For more detailed information on hand-rearing techniques, refer to the series of articles in *Clinical Management of Infant Great Apes* (Graham and Bowen, 1985).
PSYCHOLOGICAL AND SOCIAL NEEDS

The psychological and social needs of a developing infant gorilla must be recognized and should be the focus of the hand-rearing program.

The Environment

Traditionally, infant apes that required hand-rearing were removed from the adult facility and taken to a nursery (or someone's home). This approach is being challenged as more professionals realize the value of allowing the infant to grow up near conspecifics. Careful consideration should be given to setting up an area within the actual gorilla facility when an infant requires hand-rearing. This was successfully accomplished with an infant gorilla at the Toledo Zoo (Favata, pers. comm.) and a chimpanzee at the St. Louis Zoo (pers. obs.). Where this is not possible, early visits to the gorilla facility are advisable, followed by early integration.

Attention should be given to providing the infant gorilla with a stimulating and challenging environment. Initially, that may mean providing the infant a hanging mobile, stuffed toys (make sure the fur is not easily plucked and consumed), teething rings, and colorful objects. Many of the items people buy for human infants are safe and stimulating for infant apes (donated hand-me-downs are great). More complex toys, cardboard boxes, ropes, hoses, plastic chains, and structures that encourage climbing should be provided as the infant matures. Objects should be varied for added stimulation. Opportunities to exercise outdoors should be encouraged.

Many infant apes are given a "security blanket" for comfort; indeed, some caretakers recommend their use (Holtkotter and Scharpf, 1993). Although towels and blankets can be given to infants to cling to, they should not be a substitute for contact with humans or conspecifics.

Months before the resocialization effort is initiated, the infant should be thoroughly familiarized with the introduction site. The infant must be comfortable with and competent in negotiating the holding and display cages that are to be its future home. This can be accomplished by visits and playing tapes of gorilla vocalizations, and even playing recordings of the sounds associated with the gorilla facility may be advisable.

Human Caretakers

There has always been some concern among zoo professionals that hand-reared primates will become imprinted on humans and that human contact should thus be severely limited. This concern was supported by Davenport and Rogers (1970), who suggested that human-raised chimpanzees were more socially dysfunctional than chimps raised in a laboratory environment with minimal human contact. However, their data involved chimps that were not exposed to peers, thereby confounding interpretation. Reanalysis by Nissen (Fritz and Fritz, 1985) suggested that lack of peer socialization was the critical variable most responsible for the chimps' social inadequacies. Indeed, most zoo professionals are familiar with examples of hand-reared primates that were denied social access to conspecifics during childhood and as adults exhibit inappropriate sociosexual behavior.

Maple (1983) challenged the idea that intensive care provided by humans would detrimentally affect the social development of young apes. During the first several months of a
hand-reared gorilla's life, before it can be placed with peers, human contact is the only (living) source of comfort for the infant. It is incumbent on the manager to use human caretakers to replicate, as much as possible, the manner in which the infant would be raised by its mother. Continual contact for up to five months is the norm for mountain gorillas (Harcourt, 1987).

Most zoos cannot afford to assign keepers to continually hold, sit with, and play with infant gorillas that require hand-rearing. Typically, the workload of nursery and/or ape keepers includes more than these infants. Nevertheless, a zoo that takes on the responsibility of hand-rearing an ape should adjust the keepers' schedules to optimize time spent with the infant. Many keepers are innovative in finding methods to maintain contact with the infant while working at other tasks. One example is carrying the infant in a "snuggly" while working the routine. Keepers should do their best to incorporate speciesotypical maternal behaviors, such as play, appropriate carrying (e.g., dorsally at the appropriate age), and vocalizations.

It has to be remembered that an investment of time during the critical period of infancy is essential to the development of a well-adjusted animal that can live for 50 years. One to two years of intensive effort can avoid a lifetime of physical and/or social problems. In addition, the use of volunteers can overcome inadequacies in staff availability. The abundance of responsible, intelligent, caring, and experienced volunteers--human mothers--eager to assist in nurturing an infant gorilla eliminates the excuse of insufficient manpower.

Some institutions have not wanted to use volunteers because of a concern regarding the number of caretakers that can be involved in raising an ape. Although utilizing a number of people often ensures that the infant will receive more attention, some worry that multiple caretakers will detrimentally affect the infant's sense of security. No study has directly compared the effects of few versus multiple caregivers on infant development; however, Fritz and Fritz (1985) found no obvious detrimental effect on chimpanzees reared by numerous people. They report that although the chimp infants always selected a single person to whom they became most attached, they were nevertheless responsive to all caregivers. No social problems have been observed in 2.1 gorillas hand-reared by a staff of nine keepers and nine docents at the St. Louis Zoo. Eighteen caretakers is significantly more than the range of 1 to 10 and average of 4.5 caretakers used to hand-rear gorillas at 10 U.S. and European zoos (Gold, 1992). The three St. Louis Zoo infants were provided intensive human care for their first year of life, socialized with each other, exposed to adults at five months of age, and successfully integrated as a trio into an adult group at ages 17 to 27 months (pers. obs.).

Canid Companion

If sufficient human caregivers are not available, positive behavioral effects have been demonstrated in infant rhesus monkeys and chimpanzees raised with companion dogs (Mason and Kenney, 1974; Fritz and Fritz, 1985; Thompson et al., 1991). Besides being an important source of contact comfort, dogs have also served as grooming and play partners for nursery-raised chimpanzees (Fritz and Fritz, 1985). Rocking, stress-related facial expressions, and other stress-related behaviors were significantly reduced in an infant male chimpanzee when provided the companionship of a dog (Thompson et al., 1991). Dogs have been observed to chastise chimpanzee infants who play too rough by barking, snarling, or snapping at them. Such disciplinary behavior may be very beneficial to nursery-reared, peer-socialized apes that may not
normally receive such gentle discipline from humans or conspecifics when exhibiting inappropriate behavior. A collie-mix has proven to be an excellent medium-sized dog for this purpose. Infant chimps have been gradually introduced to these dogs under supervised conditions when only a few weeks old and have been housed with them through two years of age (Fritz and Fritz, 1985; Thompson et al., 1991).

Peer Socialization

Peer companionship is vital to the social development of hand-reared gorillas for several reasons. First, it allows the infant to experience physical contact and safe interactions with a conspecific while still dependent on human care. These interactions lessen the possibility that the gorillas will become imprinted on humans. Secondly, the presence of a peer companion mimics the typical social situation a wild infant gorilla would experience.

Every effort should be made to locate a peer companion for hand-reared infants. This will often require assistance from the SSP to identify whether any other similar-aged infants are being hand-reared. In the event that another infant is found, one of the institutions will need to send out their infant to benefit the social development of both. The availability of a peer by the time the infant is six months old would be ideal. At this developmental stage, the infant is more mobile and ready to initiate social interactions. It is important the age difference between the two infants is not too great, particularly if one animal is still quite young. In addition, individual personalities and abilities should be taken into account when pairing youngsters.

Initial introductions need to be carried out in the presence of two caregivers who can offer the infants security as they become acquainted with each other. If one infant becomes too rough, the caregiver can intervene by distracting or gently disciplining the aggressor, as would the mother gorilla. Interactions between the infants will have to guide the progress of the introduction and determine when the infants can be left together unattended.

When infants are comfortable and able to obtain part of their social needs from each other, the intensity of human interaction with the infants should be slowly reduced. The objective of the hand-rearing program should be to ensure that the strongest bonds in the infant's life are those between the infant and its future gorilla family and not the infant and its human caretakers. Weaning of the infant from its human caretakers will have to be a gradual process and will likely vary with the individual gorillas. When a gorilla's strongest attachment is to a human, that gorilla is set up for a lifetime of frustrated separation and potentially severe depression. (A caveat: peer rearing is not a substitute for a mixed age/sex group. Peer-reared infants should still be introduced as early as possible. Gorillas that have been peer reared to an age of 2.5 have been observed to be socially inept [Ogden, pers. comm.].)

If a hand-reared peer is not available but a parent-reared peer is being raised in the adult group, it may be possible to set up a situation that allows the parent and hand-reared infants to play together. For example, a creep door through which the parent-raised infant could join the hand-raised infant may be feasible.

Exposure and Introductions to Adults
When hand-rearing is required, it is important to integrate infants as early as possible into age/sex diversified groups of conspecifics. Exposure of the hand-reared infant to adult gorillas should begin at an early age. Ideally, the nursery is located in the gorilla facility so that the infant is immediately exposed to the smell, sight, and sound of gorillas. This may help offset the intense human interaction that this chapter recommends. It also allows the group to become familiar with the infant and may help the staff assess how to proceed with the future introduction. It should be noted that although reactions of adults to infants through the wire can often be quite telling, they may at times be deceptive. For example, at the St. Louis Zoo, the silverback would often reach through the wire and pinch the infants when they were held near him. However, it was to the silverback that the trio was first successfully introduced. Thus, what appeared to be an aggressive action may have been performed out of frustration by the male, who was unable to protect or remove the infants from the human caretakers.

The primary goal of a hand-rearing program should be to raise a well-adjusted infant who can be resocialized in a mixed-sex group. By integrating the infant into a group that contains a silverback as well as adult females (and preferably other youngsters), the infant learns male/female roles and the appropriate behaviors that should be directed to different members of a group. Hand-reared, peer-socialized juveniles that have not been integrated into an adult group have been observed to display inappropriately to silverbacks when first introduced to them (Ogden, pers. com.). It has been suggested that infants be resocialized into an age/sex diversified group at as early an age as possible (Jendry, in press). The process of introducing infants to an adult group has begun when the infants were as young as 8 to 14 months old (Jendry, in press; Favata, pers. comm.).

When the infant is sufficiently mobile (locomotes, climbs well), it is beneficial to set up a play area for the youngster adjacent to the adults. In a relaxed and safe environment, the adults and infants can observe each other in the absence of direct human intervention.

The most important rule guiding a resocialization effort is to understand each individual and the dynamics of the group as a whole. Decisions regarding the precise age at which to introduce the infant, the individual to whom the infant should first be introduced, selection of the subsequent individuals, and the procedural time frame must be based on a familiarity with all the gorillas involved. However, an open mind and careful evaluation following each step is essential. If an introduction does not proceed as predicted, the staff should be open to changing strategies.

Typically, hand-reared infants are first resocialized with an adult female or foster mother surrogate (Meder, 1985; Lincoln Park: Rosenthal, pers. comm.; Toledo: Favata, pers. comm.; Columbus: Jendry, in press; San Diego: Sexton, pers. comm.; San Diego: Ogden, pers. comm.; Brookfield: Baker, pers. comm.). The foster mother, or surrogate, can then provide the infant with security and protection when the pair is introduced to the rest of the group. Using this approach, infants have been successfully introduced before 12 months of age (Jendry, in press). The Columbus Zoo has successfully introduced 4 infants of 8, 9, 14, and 18 months of age to surrogates. However, males who are known to be gentle should not be ruled out for the initial introduction. Staff at the St. Louis Zoo first introduced a trio of hand-reared infants (male, 17 months; female, 23 months; male, 27 months) to a 30-year-old silverback. The male eased the infants' integration into the group by disciplining the two adult females when they became too
rough with the youngsters. In either case, facilitating the development of a bond between the hand-reared youngster and an adult should be the first step of the resocialization process.

The actual logistics of the introduction will be dependent on the existing facility's design, the ease with which modifications can be made to the facility, and the personalities of the gorillas. It is always best to do introductions off display. Typically, back housing offers more access in case intervention is necessary and it avoids the potential for the public to interfere with the process. In the case of introducing an infant to an adult, many caretakers prefer to set up a "creep door" situation, which serves to provide the infant with a choice to approach the adult and, if needed, may furnish an escape route. This method has been successfully used at several institutions (Baker, pers. comm.; Jendry, in press; Martinez, 1984; Schildkraut, 1985; Meder, 1985, 1992), but it is cautioned that each situation should be individually evaluated. At the St. Louis Zoo, two adults that were separated from infants by a creep door appeared to be frustrated by their inability to reach the infants. Both adults reached their arms through the opening in an attempt to lure the infants and then pull them through the opening. When the adult male was given complete access to the infants, he was much more relaxed and waited for the infants to approach him.

**SUMMARY**

1. Think ahead by developing management practices that may avoid the need to hand-rear gorillas.

2. When a birth occurs, observe the mother/infant relationship. Unless the infant's life is endangered, use the 72-hour protocol to provide time for the mother and infant to establish their relationship.

3. If the infant must be hand-reared, the goal of the program should be to resocialize it into a mixed-sex adult group at as early an age as possible.

4. The hand-rearing program should: a) provide the infant with intensive human contact to meet its early psychological needs; b) introduce the infant to the sight, smell, and sound of gorillas, preferably by being raised near the adults; c) be introduced to a peer by 6 months of age, if possible; d) wean the infant of the human/gorilla bond by facilitating the transfer of the infant's attachments to its future group; e) facilitate the introduction to age/sex diversified group as early as possible, preferably by the target age of 12 months, particularly if no peer is available; and f) utilize an adult surrogate (male or female) to insure the infant's safe integration into a group.
The housing of social animals in species-typical groupings is preferred in zoo settings, and is strongly recommended for gorillas. Housing in species-typical groupings is clearly indicated when breeding is recommended by the SSP. Further, even in instances where breeding may not be recommended, the formation of such groupings is preferred for the psychological well-being of captive animals, as well as for educational and exhibition purposes.

As stated in earlier chapters, the social structure of gorillas is well documented. The majority of gorillas in the wild are found in single-male harem units, with one silverback male and multiple females and young (e.g., Harcourt, 1979). Additionally, field reports indicate that—in the case of mountain gorillas, at least--multi-male groups are more common than originally thought (Robbins, 1991), and all-male groups and solitary males have also been observed (e.g. Stewart and Harcourt, 1987; Sholley, 1990). To create such social groupings with captive gorillas, as well as to translocate captive animals to comply with breeding and socialization recommendations, introductions will often be necessary.

The literature available on captive gorilla socializations primarily describes individual case studies of successful introductions. There are few studies that attempt to document the behavioral changes during a socialization that predict success (e.g., Bennett and Fried, in preparation); the current data are largely anecdotal. In general, however, the anecdotal data suggest that "positive behaviors" or "comfort-related behaviors" (Jendry, in press), such as affiliative behaviors, can predict success. "Negative behaviors" and "stress behaviors" (Jendry, in press), or those presumed to be associated with stress, indicate that the introduction is not ready to proceed (see below).

The type of social group desired—single-male harem groups—will affect the strategy for introduction. Further, introduction strategies are affected by factors such as the age and temperament of the animals involved and the experience of the staff. Knowledge of each gorilla's behavior is vital during each introduction to ensure the safety of all individuals. Zoo staff should communicate with the "home zoo" to gain specific animal behavior information on the new individual prior to beginning any introduction. All introductions are individual and, to some extent, may be based on trial and error. However, the principles suggested by Lindburg (1986) in his cross-species guideline for animal introductions may be applied. Lindburg suggests three guidelines for reducing conflict during introductions: 1) allow integration to proceed as far as possible before actual physical contact; 2) decrease the influence of dominant individuals; and 3) manage the physical environment to reduce negative interactions.

ALLOWING INTEGRATION TO PROCEED BEFORE PHYSICAL CONTACT

When introducing a group of wholly unfamiliar animals, some institutions have reported
success in simply introducing all unfamiliar animals at once. However, others have had difficulty in such circumstances, and integration is typically a multi-step process, which we recommend. The multi-step process reduces variables and should, therefore, help reduce the risk of injuries during introductions. There are many individual steps that can occur:

1. distal, visual, olfactory, and auditory contact.

2. limited tactile contact through socialization mesh, reducing the possibility of grabbing or biting. During this step, bedding and forage food can be placed on both sides of the mesh to encourage noncompetitive interaction.

3. limited tactile contact through cracked door (some institutions have eliminated this step because of the possible risk of injury).

4. full physical contact, including escape routes and complex physical environment.

These steps may also be implemented for a presocialization subgroup, prior to the full group introduction.

**ROLE OF STAFF**

The staff, facilities, and, of course, the individual animals are key to the success or failure of any introduction. Regular communication between the various players is critical and, ideally, the team would include keepers, curators, veterinarians, and research staff. This group should meet regularly during the introduction process. Given the visible nature of gorillas, public relations staff should be kept informed about the introduction process, and methods for educating the public about potential successes and failures of the introduction should be developed. The team should discuss the socialization plan thoroughly and determine the criteria for moving from step to step, as well as alternative plans of action.

**PROGRESSION FROM STEP TO STEP OF THE INTRODUCTION**

The length of time spent in each phase is dependent on many factors, including, but not limited to, the previous experience of both the staff and the gorillas in introductions, the flexibility of the gorilla socialization facilities, and the temperaments of the individual gorillas involved. If a zoo has limited experience with introductions, it is recommended to contact people at other zoos who have successfully completed introductions. Colleagues may also provide videos of introductions, both successful and unsuccessful. Close observation of the process should be maintained, either by the primary caregivers or by supplementary research observers. Whenever unfamiliar people are involved (e.g., to collect data), these individuals should be given time around the gorillas to allow for habituation prior to the socialization process. Behavior may be assessed either informally or via systematic data collection with the data continually analyzed and used to assist the decision-making process. Video documentation can be useful to evaluate the introduction and can also be reviewed by staff members not present.
The staff may use many factors to determine progress during the socialization. In general, however, "positive behaviors" indicate that the introduction is moving forward, while "negative behaviors" indicate that the introduction is not ready to proceed. Behaviors associated with stress may include: diarrhea, agonism, displays, screaming, inappropriate dominance behaviors (e.g. staring, not withdrawing when faced with an aggressive male, etc.), taking of objects, and abnormal behaviors such as self-clasping, self-biting, and hair plucking. Positive behaviors may include: affiliative behaviors, such as proximity, contact, and giving of objects, sexual behavior, and appropriate submissive behavior (e.g. averting eyes, etc.). Neutral behaviors, such as feeding, may also be used to evaluate the process; for example, a significant decrease in feeding may be indicative of stress. Observations of food sharing and play may be indications to proceed, whereas increased levels of displays and aggression may be indications to slow down or stop the introduction. It should be noted that an absence of negative behaviors may be taken as a positive indication. Further, proximity may be the primary "positive" behavior observed; giving objects is more infrequent.

**DECREASING THE INFLUENCE OF DOMINANT INDIVIDUALS**

**ESTABLISHING PRE-SOCIALIZATION BONDS**

It is commonly recommended to establish bonds between younger, smaller individuals and older, larger females prior to introducing them to a silverback male. This provides the younger animals with potential protection. When introducing juveniles and subadults to adults of both sexes, it is commonly recommended to select an animal or animals from the primary group for the first phase of the full physical contact step of the introduction. The primary group animals used for the pre-socialization phase should be determined by staff, based on their observations of previous steps and introductions. It is helpful to understand the dynamics of coalitions in the primary group. Staff should determine which coalitions can be used to promote a safe introduction and may choose to separate animals in coalitions that could slow down to hinder the socialization process. The potential exists for forming bonds, and this could benefit the new individual when the silverback is introduced. The silverback generally should be the last animal introduced, but exceptions do arise, and staff must be prepared to explore all options.

This bonding process will typically necessitate separating out one or more animals from the primary social group for pre-socialization with the new individual. Care should be taken in doing this, so as not to cause significant damage to the social bonds in the primary group. This can be minimized by introducing the new animal to the subgroup for a few hours each day and returning the subgroup to the primary group for the rest of the day. As the new individual becomes more comfortable, time spent together can be gradually increased, with the subgroup rotating to the primary group only at night. Using these steps in the pre-socialization phase, the new animal should benefit and the primary group's bonds should not deteriorate.

**NUMBER OF ANIMALS PRESENT**
Increasing the number of animals present during an introduction may also diffuse possible aggression from dominant individuals. The most difficult step of a gorilla socialization is generally the introduction of the new member to the silverback male. Typically, it is recommended that the introduction include a group larger than the male and the new member; other group members may aid the new member in defending against the male.

MANAGING THE ENVIRONMENT TO REDUCE NEGATIVE INTERACTIONS

MANAGEMENT OF PHYSICAL ENVIRONMENT

The physical environment can greatly affect the success or failure of an introduction. The environment can be managed to decrease the influence of dominant animals. One way to accomplish this is to provide escape routes for the "new" or smaller individuals. In particular, the introduction area should be circular, and should not include places where animals can be trapped (Mager and Griede, 1986; Keizer, 1994). The holding facility and exhibit area should first be evaluated and necessary changes made. A "socialization area," such as two areas divided by a double-mesh screen to allow safe, limited tactile contact, may need to be added.

FACILITY CHARACTERISTICS

The introduction room should include visual barriers, as well as escape routes and retreats for new individuals or smaller animals. Additionally, an introduction area should not include any alleys or other areas where animals might get trapped. The area should be furnished with objects to encourage displacement, including browse, ropes, hay, straw, cardboard boxes, paper, forage food, etc. The environment should be complex, giving all animals many choices. If only a few items are included, aggressive or competitive behavior may result.

NEUTRAL GROUND

First, it is generally preferable for an introduction to be carried out in an area that is neutral territory for all participants. Ideally, this would be an area that is not a home exhibit for any of the involved animals. Prior to the full physical introduction, all animals should have experience with the area, in order to ensure familiarity with escape routes.

The full introduction may be conducted indoors or outdoors, depending on available facilities. In general, most staff prefer to use indoor areas, due to the increased control that they perceive in these environments. However, it can be argued that outdoor areas are generally more complex, providing more escape routes. When exhibit areas are used, the public should be kept out of the area until the introduction is complete. Regardless of whether an indoor or outdoor area is used, remember that at some point the introduced group will need to experience the other area; at that time, that facility should be supplied with objects such as those described above.
INTERVENTION PLANS

Particularly for the higher risk, full physical contact phase of the introduction, the staff should have a complete plan for when and if intervention will occur and what form such intervention should take. Staff should have available items such as hoses, fire extinguishers, and even veterinary tools for possible anesthetization. However, staff should take care in using these objects. Few gorilla introductions will occur without any aggression. Each institution will vary as to the amount of aggression it will allow prior to intervening; however, institutions should be aware that aggression is, in fact, a species-typical behavior during gorilla immigrations, and that gorillas in the wild have been observed to sustain and recover from substantial wounds without veterinary assistance. Further, overuse of intervention tools, such as fire extinguishers or hoses, may serve to reinforce aggression--both by reinforcing halts to the socialization process and by punishing interaction. It may instead be better to allow an aggressive encounter to calm down and some reconciliation to occur before checking wounds. Again, when possible, observers should view videos from other introductions in order to help them anticipate what might occur.

INTRODUCTION OBSERVATIONS

Staff must determine who will be observing the process. We would recommend that the gorillas be well-habituated to all of those individuals present during the introduction. Further, the number of individuals present should be kept to a minimum; if a large number of people are interested in observing the process, remote video viewing can be set up in an area separated from the introduction area.

SPECIAL CASES

HANDRAISED ANIMALS

As discussed in the birth management section, handraising infants is clearly not recommended. However, when it is necessary to remove gorilla infants for hand or peer-rearing, these infants should be integrated into a group as soon as possible (Meder, 1985; Jendry, in press). Although aggression toward infants is rare among familiar gorillas, infanticide has been reported in wild gorillas (Watts, 1989), possibly up to the age of three years. As a result, this is a factor that must be considered during introduction. It is recommended that young animals establish a strong bond with a female that will be able to protect them during potential conflicts with the male. Females that may be suitable are those who have exhibited "aunting" behavior in the past and that have a strong relationship with the male.

At a very early age (2 to 4 months old), an infant should initially be allowed to spend time around the family, becoming familiar with the keepers, the facilities, and the gorillas.
Approaching or at the age of weaning, the infant can begin physical introduction to a female, and possibly to another young animal, that may serve as an eventual playmate. If supplemental feedings can be incorporated, the process can begin much earlier (e.g., 7 months of age). This will also depend on factors such as the age and experience of the other gorillas, the presence of surrogates, etc. Some authors strongly recommend introductions before the first year of age in order to facilitate both the introduction process and normal social development (e.g., Jendry, in press; Meder, 1989). Several institutions have been successful at socializing an infant prior to weaning age, and supplementing this introduced animal with bottles (Cole, pers. comm.; Favata, pers. comm.; Jendry, pers. comm.; Ogden, pers. comm.). The dynamics of the entire primary group and, particularly, the predictability of the silverback is vital to ensure the safety of infants during and following their introductions.

INTRODUCTION OF ADOLESCENT OR OLDER MALES

As the proportion of male to female gorillas in captivity increases, zoos are being encouraged to form multi-male groups, or even all-male groups. As a male gorilla passes juvenile status, the introduction of males to any group that includes a silverback male becomes more difficult. As a result, such introductions are quite complex and time consuming. Some institutions (e.g., St. Louis Zoo) have been successful at forming multi-male groups, and those facilities interested in pursuing this possibility are encouraged to contact them for detailed information (Porton, pers. comm.).

ADULT OR SUBADULT FEMALES

In general, follow the multi-step process when introducing adult females. To facilitate bonding, we recommend first introducing the female to other group members before introducing the silverback (when introducing a female and the silverback, doing so during estrus may facilitate the introduction process). As previously stated, care should be taken in doing this, so as not to cause significant damage to the social bonds in the primary group.

USE OF BEHAVIOR MODIFICATION

Behavior modification techniques have been used with some species to reinforce appropriate behaviors and discourage inappropriate behaviors for socialization. For further information, see Snowden and Sevenich, this volume.

USE OF TRANQUILIZERS

In special circumstances, institutions may choose to use tranquilizers, such as valium, during introductions. This has been tried with success (Gold, pers. comm.).
SUMMARY

1. More systematic data on variables related to successful introductions are needed.

2. Lindburg's (1986) general guidelines on successful animal introductions can be applied to gorillas:
   a) allow integration to proceed as far as possible before actual physical contact;
   b) decrease the influence of dominant individuals such as by developing bonds between "new" animals and established adult females;
   c) manage the physical environment to reduce negative interactions, including providing physical complexity, visual barriers, and escape routes, as well as ensuring that all animals are thoroughly familiar with the area.

3. Involvement of and communication between staff at all levels is vital to successful introductions.

4. Progression from step to step is dependent on careful observation of the gorillas--in general, affiliative (e.g. proximity), or neutral (e.g. feeding) behaviors provide an indication to move forward.
KEEPER SAFETY

J. Doherty

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

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

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

4. Lock all locks unless specifically instructed not to.

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

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

7. Know how many animals are in an enclosure before and after shifting them. Before shifting an animal, know where all other keepers in the area are.

8. Always lock shift doors before entering an animal enclosure. Always lock shift doors between animals.

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

10. Before entering a cage or enclosure, know: a) the species and sex of animals in the area; b) the number of animals in the area; c) the location of each animal (if possible).

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

12. When entering an enclosure that contains animals, be sure the animals are aware of your presence so they will not be frightened by your sudden appearance. Carry something with you (a rake, shovel, or net) that can be placed between you and the animals if necessary.

13. Whenever possible, shift animals out of cages or enclosures before entering.

14. When working in with animals, avoid direct eye contact, and never crowd them, corner them, or walk between them. Walk along perimeter walls or fences whenever possible.

15. Do not speak unnecessarily to other keepers when working in with animals or interacting
with animals.

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

17. Always move with extra care around animals just prior to, and during feeding time.

18. Never hand-feed an animal unless specifically told to do so.

19. If special equipment is provided for feeding certain animals, use it.

20. Be especially careful around mothers with newborns or males during their breeding season.

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

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

23. Never mix cleaning and disinfecting chemicals.

24. Avoid wearing excessive jewelry (rings, bracelets, chains, etc.) that can get hung up on hooks or can be grabbed by animals.

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

Remember, failure to follow established safety procedures can result in an injury to an animal, yourself, a co-worker or the public. Always think safety!
DANGEROUS ANIMAL ESCAPES

J. Doherty

If you are involved in any situation where potentially dangerous animals have escaped, there are a few things you should keep in mind. Remember, fast action may be crucial for the safety of visitors, employees, and the animals, but also remember not to be so fast that you are careless. Cool heads must prevail!

POINTS TO REMEMBER DURING THE EMERGENCY

1. Identify exactly what has escaped.
2. Locate the escapee or escapees as quickly as possible.
3. Inform the director or curator in charge about which person will be assuming responsibility for the recapture and directing all involved.
4. A perimeter of keepers should be formed, at a safe distance, to contain the animal and exclude those not involved.
5. The staff officer in charge will initiate a strategy to recapture the animal.
6. Security and other staff personnel should be stationed to move bystanders away, into buildings, or out of the park, if necessary.
7. Radio communications should be as clear and brief as possible.

RECAPTURE PROCEDURES

1. Close any doors or gates that might possibly contain the escaped animal or animals.
2. Go to a phone or radio and inform staff members of the escape. If there is a chance of the escaped animal getting out of sight or getting into an area where it might be difficult to locate, try to stay safely within sight of the animal and have another person notify help.
3. The first person to be notified by phone or radio should be the director or curator in charge. Provide the following information as fast as possible: a) what has escaped? b) where is it? c) which way is it moving? d) what is already being done to contain it?
4. The director or curator in charge should notify the head of security, the veterinarian, and other required staff people.
5. The head of security should notify the city police and provide the following information:
a) what is known about the escape situation; b) what is being done about recapturing or containing the animal or animals; c) where and how they can reach you for further information or instructions.

6. The veterinarian will be responsible for the use of tranquilizing equipment or will instruct others in its use.

7. Back-up assistance from other members of the staff should include: a) providing any manpower, vehicles, radios, fire extinguishers or other equipment required; b) maintaining radio silence unless requested--all unrelated radio messages must be deferred during a dangerous animal escape; c) not leaving an assigned work area during an escape until asked to respond--knowing where people are during an escape is preferable to having people roaming at will, possibly into a dangerous situation.

**WEEKEND OR HOLIDAY ESCAPES**

1. The officer of the day should be notified. This person will contact the director, curator, security staff, veterinarian and anyone else required.

2. The supervisor in the appropriate animal department will take charge of the situation and direct efforts until relieved by a senior staff member (see above).

During an animal escape, the chief concern is protecting the public and zoo personnel. Especially critical is the situation where a dangerous animal escapes from an enclosure and immediately confronts the public. Although every effort should be made to keep the public back from an escaped animal and to allow the veterinarian to immobilize it, situations may become critical and the escaped animal may have to be shot. For safety, vehicles should be used, when possible, for surveillance, tranquilization, or shooting.

**GENERAL PRINCIPLES IN DEALING WITH ESCAPED ANIMALS**

1. Each animal has its own flight distance. This is the distance at which the animal will flee from a pursuer. In captivity, the flight distance is lessened when the animal is contained by moats, fences, etc. Once escaped, the flight distance is likely to become much greater, due to the absence of these containments. An animal usually has a shorter flight distance for a vehicle than for a man on foot. Where practical, use a vehicle.

2. The escaped animal is frightened. Given the opportunity, it will move back toward familiar surroundings. To make the animal move, you only have to violate the flight distance. Use this to your advantage. If you are trying only to contain the animal, simply do not violate the flight distance.

3. Each animal also has a critical distance. This is the distance at which the animal will attack a pursuer. If an animal is cornered and you have gone inside its flight distance, you
will be approaching its critical distance. Now you must be especially careful.

4. An escaped animal is in a strange situation and may feel quite desperate. Animals usually have a strong attachment for their home enclosure. Thus, if the animal has not ventured far from its enclosure, it may be possible to lure or herd it back inside. Give it a chance to return.

5. When a dangerous animal escapes, it may have a severe alarm reaction to the sight of a rifle or pistol used in darting procedures. Therefore, it is important that the people on the scene who have firearms conceal them. There have been cases in zoos where dangerous animals, such as tigers, have attacked people carrying rifles with amazing speed. Other appropriate guns should be available for protection of the surrounding people; but if at all possible, these guns should be concealed to minimize the adverse effect they may have on the animal.

6. Examples of positive stimuli that will calm an animal are: being near a familiar area, sensing familiar people or animals, food, and coaxing sounds the keeper normally makes.

7. Keep an eye on the mood of the animal. Just by examining the animal's expression, stance, or other factors, you can tell whether the animal is anxious, calm, about to flee, or about to attack. Act with common sense.

**USE OF CO2 FIRE EXTINGUISHERS IN ANIMAL CONTROL**

1. Use only CO2 type fire extinguishers.

2. Use only in a very dangerous or life-threatening situation. Use in short bursts.

3. The main effectiveness of CO2 is the element of surprise: a) the animals are unfamiliar with it; b) it makes a lot of noise; c) it creates "smoke."

   **Warnings in Using a Fire Extinguisher**

1. Do not discharge the extinguishers directly at the animal. Use the "smoke" to push the animal in the direction you want it to move.

2. By using this "tool," you actually lose more control over the animal and the situation--it makes the animal less predictable.

3. There is no way to predict how an animal will react to the extinguisher, and the same animal could react to it differently at different times.

4. Remember, a CO2 extinguisher will discharge for approximately 15 to 20 seconds before emptying. For this reason, do not continue to use it if the animal is doing what you want
it to do.

5. Again, this tool is to be used only in very dangerous or life-threatening situations. This cannot be stressed enough.

6. CO2 extinguishers have very limited effectiveness in animal control. Great care must be taken in their use.

**EMERGENCY PHONE NUMBERS**

List the names and home phone numbers for any staff who might be involved in the recapture of a dangerous animal. The list should be part of the zoo's emergency manual or posted where it is easily seen.

**DANGEROUS ANIMAL ESCAPE RESPONSIBILITIES**

Assign specific responsibilities to each member of the animal management staff. For example:

1. Curator: responds to the scene to evaluate the escape and direct the operation.

2. Collections manager: collects firearms and ammunition and carries them to the escape scene.

3. Supervisor: collects nets, fire extinguishers, ropes, etc., that might be used to help contain or capture the escaped mammal.

4. Keepers: be prepared to assist as instructed.

**APE HOUSE ESCAPE PROCEDURES**

Escapes within the Building

1. If safely possible, close all building doors to contain the gorilla in the building. Also, if possible, close any alley doors or barred doors to further restrict movement.

2. Immediately alert your partner to the situation via radio.

3. Evacuate the public from the building.

4. Notify mammal department curators and supervisors of the escape and give the following information using the "Mr. Houdini" code: "We have a Mr. Houdini at the Ape House." Follow with this information: a) which gorilla(s) has escaped; b) where it is located (if
known), and if it is contained.

5. Wait for assistance. Keep calm. Do not try to return the animal to its enclosure until help arrives from curators, supervisors, and veterinarians.

Escapes Outside of Building

1. Immediately alert your partner to the situation via radio.

2. Notify mammal department curators and supervisors of the escape using the "Mr. Houdini" code.

3. Notify keepers in nearby installations to help in forming a perimeter to exclude the public.

4. If it can be done safely, open doors to any area that can serve to temporarily contain the gorilla.

5. Also, if it can be done safely, try and contain the escapee by offering favored foods.

6. Try to maintain visual contact from a safe distance.

7. Await help. Do not attempt to return the animal to its enclosure until help arrives from curators, supervisors, and veterinarians.
Gorillas (Gorilla gorilla) pose an interesting and challenging dietetic study. Some differences exist among the diets of the three subspecies, probably due to habitat variation; unfortunately, most field work has focused on the subspecies not represented in zoos.

Mountain gorillas are primarily folivores (Harcourt and Fossey, 1977; Watts, 1984; 1985). Their diet consists primarily of foliage of herbs and vines, with leaves making up 68% of intake, stems 25%, pith 2.5%, epithelium from roots 1.4%, and the remaining 4% from bark, roots, flowers, and fruit. The western lowland gorilla apparently consumes more fruit (Williamson, 1990; Nishihara, 1992; Tutin and Fernandez, 1993); however, green plant material remains the majority of the diet. Calvert (1985) concluded that, of the plant species consumed by western lowland gorillas in Cameroon, 23% of the species were vines, 38% herbs, 24% saplings, and 15% trees. Western lowland gorillas in Gabon consume slightly different proportions of food than do mountain gorillas, with leaves and stems accounting for twice the intake of fruit (Tutin and Fernandez, 1993). Tutin also reports that many foods consumed overlap with that of common chimpanzees occupying the same range. Gorillas seem to shift their food intake according to seasonal variations and food availability (Nishihara, 1992; Tutin and Fernandez, 1993). Calvert (1985) found no evidence of animal matter being either consumed or found in the feces. The eastern lowland gorilla diet appears to be closer to that of the western lowland gorilla than that of the mountain gorilla, but little literature exists.

Free-ranging gorillas consume a wide variety of plant species, with 50 to 300 species reported (Calvert, 1985; Rogers et al., 1990). However, they are very selective, choosing only certain parts of the vegetation at certain times of the year (Rogers and Williamson, 1987; Williamson et al., 1988). Base and tips of young leaves are eaten (i.e., Haumania liebrechtsiana and Megaphrynium gabonense); mature as well as young leaves are also eaten in some species (Milicia excelsa); and in many species, only mature leaves were consumed (Rogers et al., 1990). Aframomum seems to be an important genus to gorillas at all study locations. Even captive gorillas are selective feeders, with particular species and plant parts preferred by individuals and groups (J. Ogden, San Diego Zoo, unpublished data).

Gorillas generally select immature leaves over the mature ones, which usually contain less fiber, more protein, and less secondary components such as tannins (Hladik, 1978; Milton, 1979; Rogers et al., 1990). Shoots, flowers, and fruit are also preferred over mature leaves (Clutton-Brock, 1975; Casimir, 1975). Woody vegetation species are not avoided (Calvert, 1985). Rogers et al. (1990) conducted the most complete chemical analysis of the diet of the western lowland gorilla in the Lope Reserve, Gabon. The gorillas in Lope Reserve do not appear to select food based on any anti-nutritional properties (i.e., phenolic compounds), and consume a
wide variety of fruit from highly proteinaceous unripe seeds to sugary fruit. They seem to avoid unripe and higher-fat fruit.

Fruits consumed by gorillas are much more fibrous than our traditional idea of cultivated fruits commercially available in the west. Thus, from a nutritive perspective, caution must be used to interpret wild dietary data based on percentages of vegetation and fruit intake. Fruit consumed by the gorilla typically can have the same or even higher levels of dietary fiber as leaves (as shown in Table 1. (Data from Calvert, 1985; Rogers et al., 1990.)

Table 1. Range of nutrient composition of food categories consumed by western lowland gorillas in Cameroon and Gabon (adapted from Calvert, 1985; Rogers et al., 1990; values except water on a dry matter basis).

<table>
<thead>
<tr>
<th>Food</th>
<th>Moisture</th>
<th>Crude Protein</th>
<th>Crude Fat</th>
<th>WSC</th>
<th>NDF</th>
<th>ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>% of dry matter</td>
<td>% of dry matter</td>
<td>% of dry matter</td>
<td>% of dry matter</td>
<td>% of dry matter</td>
</tr>
<tr>
<td>Leaves (n=24)</td>
<td>50.0 to 88.5</td>
<td>10.6 to 32.2</td>
<td>0.6 to 13.5</td>
<td>0.2 to 8.0</td>
<td>21.3 to 72.6</td>
<td>16.5 to 58.0</td>
</tr>
<tr>
<td>Shoots (n=5)</td>
<td>85.7 to 92.4</td>
<td>8.4 to 13.8</td>
<td>2.1 to 3.8</td>
<td>63.3 to 80.4</td>
<td>48.4 to 54.1</td>
<td></td>
</tr>
<tr>
<td>Stems and Bark (n=23)</td>
<td>54.4 to 94.9</td>
<td>2.6 to 17.1</td>
<td>0.4 to 5.7</td>
<td>34.7 to 81.9</td>
<td>34.8 to 61.8</td>
<td></td>
</tr>
<tr>
<td>Fruit (n=18)</td>
<td>34.0 to 88.9</td>
<td>0.9 to 13.8</td>
<td>0.2 to 20.9</td>
<td>13.1 to 62.4</td>
<td>55.1 to 82.3</td>
<td>4.8 to 66.5</td>
</tr>
<tr>
<td>Seeds (n=9)</td>
<td>43.1 to 78.6</td>
<td>4.1 to 18.4</td>
<td>0.3 to 12.0</td>
<td>2.3 to 25.7</td>
<td>43.1 to 78.6</td>
<td></td>
</tr>
</tbody>
</table>

WSC=water soluble carbohydrate; NDF=neutral detergent fiber; ADF=acid detergent fiber

Native gorilla vegetation has an extremely high fiber content, which cannot be digested in the stomach or small intestine, but must be fermented in the large intestine by gut microbes to produce short chain fatty acids (SCFA), carbon dioxide, and methane. Gorillas have an enlarged hindgut for harboring such bacteria (Stevens, 1988), and SCFAs are likely used by gorillas and even humans for energy production and colonic health. However, no metabolic studies have been conducted.
A total of 37 zoos responded to food frequency questionnaires. The diet varied considerably from zoo to zoo, with more than 115 distinct food items fed regularly, occasionally, seasonally, or as a treat. Ten of the zoos (27%) offered between 11 and 15 different food items daily; 10 (27%) offered between 16 to 20 items daily; 3 zoos (8%) offered more than 20 different items daily. The remaining 14 zoos offered 10 or fewer items daily.

Overall, the zoos fed an average of three meals per day, which were usually scattered in the exhibit. The majority of zoos (n=27; 73%) use commercially prepared diets in addition to produce, while 10 zoos (27%) prepare their own staple diet. Six zoos fed meat on a regular or occasional basis.

Twenty different vegetables were fed on a daily basis. The majority of zoos fed carrots (79% of the zoos), sweet potatoes/yams (71%), green beans (38%), onions (29%), white potatoes (29%), corn on the cob (12.5%), and leeks (12.5%). Twenty-three different fruits were fed on a regular basis, with the majority of zoos feeding apples (96%), bananas (89%), oranges (85%), grapes (48%), fruit juices (22%), raisins (19%), and tomatoes (11%). Twenty-five different types of greens/browse were fed, including celery (89%), lettuce (71%), spinach (54%), kale (46%), broccoli (43%), cabbage (25%), willow browse (21%), parsley (14%), escarole (14%), and cauliflower (14%). Eighteen different types of cereals/grains were fed, with a majority of zoos feeding bread (86%), sunflower seeds (79%), peanuts (57%), mixed nuts (29%), popcorn (29%), and white rice (14%).

Nineteen different commercial products were fed, with the primary staple comprising Mazuri Old World Primate (fed by 32% of the zoos), Purina (Lab Diet) High Protein (20%), Marion Leaf Eater Biscuit (20%), Spectrum Primate Pro-Plus (16%), HMS High Fiber Primate (16%), Mazuri Leaf Eater (12%), Zu/Preem Primate Dry (8%), and Purina Lab Diet (8%).

Animal products including meat, eggs, milk, and yogurt were fed to the gorillas with frequencies as shown in Table 2.

### Table 2. Frequency of Animal Products Fed to Gorillas in North American Zoos (surveyed 1995).

<table>
<thead>
<tr>
<th>Animal Products</th>
<th># Zoos Feeding</th>
<th>Regularly (daily)</th>
<th>Occasionally (1-2 times/wk)</th>
<th>Treat (1-2 times/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Eggs</td>
<td>19</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Milk</td>
<td>18</td>
<td>10</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Yogurt</td>
<td>21</td>
<td>4</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>
A macronutrient profile was developed using a modified computerized USDA database with modification for dietary fiber values; this included limited preliminary analysis of some browse (Wildlife Conservation Society) and commercial primate mixtures.

**Evaluation of Adequacy**

Information from the surveys described diets offered, not consumed, by captive gorillas. Adequate detail for assessing nutrient composition of offered diets was available from diets of 18 adult males, 18 adult females, and 14 juveniles. The calorie content of food items was calculated based on metabolizable energy (ME) values for humans (Watt and Merrill, 1975) or, in the case of commercial products, from energy estimations provided by manufacturers. Metabolizability of browses was estimated at 50 percent. Metabolic studies have not been published for gorillas; values for produce items based on humans may underestimate actual caloric contributions for gorillas due to the increased complexity of the gorilla hindgut. Nonetheless, these values provide some interesting speculation on diet composition.

Caloric needs of the gorilla can be estimated from the general energetic equation of Kleiber (1947), where basal metabolic rate (BMR) = 70 kcal x (body mass in kg)\(^{0.75}\). Adult maintenance energy would then be estimated as 2 x BMR, and growing animals 3 x BMR. Thus, for captive gorillas ranging from approximately 20 kg. (juvenile) to 220 kg. (adult male), energy needs would theoretically be met with 1990 to 8000 kcal/day. Body mass estimates used throughout this report include 150 kg. for adult male gorillas, 100 kg. for adult females, and 50 kg. for growing juvenile gorillas. Although ranges were wide ( giả 50%), diets offered to zoo animals in this survey appeared to provide adequate energy (Table 3); some surveys noted obese animals.

**Table 3. Calculated metabolized energy content of diets offered to zoo gorillas in North America, compared with theoretical requirements based on metabolic body size.**

<table>
<thead>
<tr>
<th>Body Mass (kg)</th>
<th># Diets Evaluated</th>
<th>Amount offered in kg (as fed)</th>
<th>Amount offered in kg (dry)</th>
<th>Mean kcal in diet offered</th>
<th>Estimat-ed kcal requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Male</td>
<td>150</td>
<td>17*</td>
<td>7.05</td>
<td>1.98</td>
<td>7100 (2 x BMR)</td>
</tr>
<tr>
<td>Adult Female</td>
<td>100</td>
<td>18</td>
<td>4.17</td>
<td>1.24</td>
<td>5600 (2 x BMR)</td>
</tr>
<tr>
<td>Juvenile</td>
<td>50</td>
<td>14</td>
<td>3.25</td>
<td>0.86</td>
<td>4420 (3 x BMR)</td>
</tr>
</tbody>
</table>
*Outlier excluded from analysis

Dietary amounts offered to gorillas in the survey ranged from 4.7% of body mass (adults; as-fed basis) to 6.5% for juveniles. On a dry matter basis, amounts ranged from 1.0% (adult males) to 1.3% (adult females) of body mass. Herbivorous mammals typically consume 1 to 2.5% of dry matter on a daily basis. On an as-fed basis, diets offered comprised the following ingredient categories (Table 4):

Table 4. Dietary ingredients (by category) offered to gorillas in North American zoos, expressed as percentages on an as-fed basis (results of survey, 1995).

<table>
<thead>
<tr>
<th></th>
<th>% Fruit</th>
<th>% Vegetables</th>
<th>% Greens/Browse</th>
<th>% Commercial Products</th>
<th>% Cereals, Nuts &amp; Seeds</th>
<th>% Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult male</td>
<td>27.9</td>
<td>26.9</td>
<td>24.6</td>
<td>14.7</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Adult female</td>
<td>26.6</td>
<td>27.6</td>
<td>27.6</td>
<td>11.0</td>
<td>3.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Juvenile</td>
<td>27.3</td>
<td>25.2</td>
<td>25.3</td>
<td>11.0</td>
<td>3.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Young, growing animals were offered more animal-based foods (eggs, milk, yogurt, meat) than adults, but mean overall percentages of food groups did not vary dramatically among age/sex groups. Diets, however, varied considerably depending upon the facility surveyed. The percent of fruit in the diet varied from 10% (all groups) to 51% (adult males) of food offered. Vegetables (including tubers, roots, legumes, and stalks) ranged from 6% (adult males and juveniles) to 50% (adult males) of diet, whereas dark green leafy vegetables and browse ranged from 0% (adults) to as much as 60% (males) of diet. Commercial products comprised as little as 2% of diet as offered, up to a maximum of 55%; seeds, nuts, and cereal grains equalled 0% to 17% of total diets as-fed. Animal-based products composed up to 33% of total diet offered to some juveniles. Browse types fed to gorillas in this survey are identified in Table 5.

Table 5. List of browse offered to and consumed by gorillas in North American zoos (surveyed 1995).

- **Acer** sp: maple
- **Salix** sp: willow
- **Liquidambar** sp: sweetgum
- **Ficus** sp: ficus
- **Celtis** sp: hackberry
- **Musa** spp: banana, daikon
- **Diosporos** sp: persimmon
- **Acacia** sp: acacia
- **Malus pumila**: apple
- **Lonicera** spp: honeysuckle, white ash
- **Prunus** spp: Kaffir plum, passion vine
- **Rosa** spp: roses
- **Helianthus annuus**: sunflowers, sweet potato vine
- **Hemerocallis** spp: day lilies, herbs
- **Vitis vinifera**: grape
- **Eugenia** sp: eugenia
- **Hibiscus** sp: hibiscus
- **Morus** sp: mulberry
Composition of diets offered was calculated using a commercial software program (Animal Nutritionist, N^2 Computing, Silverton, OR) based on amounts and ingredients in the survey. Macronutrient profile was developed using a computerized USDA database with modifications for dietary fiber values, preliminary analyses of browse (Wildlife Conservation Society), and commercial primate mixtures. Intake was not measured; nutrient profile estimates in Table 6 are based on diets provided.

**Table 6. Mean macronutrient profile in diets offered to gorillas in North American zoos.**

<table>
<thead>
<tr>
<th></th>
<th>Moisture %</th>
<th>% of dry matter</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>%</td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>71.9</td>
<td>16.4</td>
<td>5.8</td>
<td>14.1</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71</td>
</tr>
<tr>
<td>Female</td>
<td>73.6</td>
<td>15.7</td>
<td>6.3</td>
<td>14.7</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71</td>
</tr>
<tr>
<td>Juvenile</td>
<td>73.4</td>
<td>16.6</td>
<td>7.0</td>
<td>13.7</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>68</td>
</tr>
</tbody>
</table>

Zoo diets contained one-half to one-fifth the fiber level analyzed in native foods eaten by lowland gorillas, and about twice the fat content. Digestion data were not available for zoo gorillas, but passage has been estimated at 36 to 38 hours (Milton, 1984). Diets consumed by free-ranging animals have been estimated to be no more than 50% digestible (weighted mean, individual plants ranged from 4.6% to 81.3% digestibility using a cellulose/pepsin in vitro digestion technique (Calvert, 1985). Data reported here suggest a much higher diet digestibility, and relatively unchallenged fiber fermentation capabilities.

**Health Risks Linked to Diet**

Captive gorillas can be compared with westernized humans; they are both displaced from their natural diet and lifestyle and are thus at risk for specific diseases. Gorillas are vegetarians, consuming no animal products. This may be essential for health, as elevated cholesterol levels (281 to 311 mg/dL, McGuire et al., 1989) have been reported in zoo gorillas, leading to premature cardiovascular disease. Human subjects with the same values would be considered hypercholesterolemic and at risk for heart disease. Cardiac arrest associated with a poor diet and
lack of exercise in captivity has been cited as a significant cause of adult gorilla deaths in zoos (Cousins, 1979).

Gorillas on relatively low fiber diets may also be prone to ulcerative colitis, an intestinal disorder (Scott and Kemer, 1975). These intestinal disorders may be prevented by a fiber-derived short chain fatty acid, butyrate, which is a preferred energy substrate for colonic mucosal cells and has been shown to have antineoplastic properties (Roediger, 1982; Weaver et al., 1988). Vegetables, and to some extent fruits, have many components that may play a major role in the prevention of disease, including dietary fiber, folic acid, antioxidant vitamins (vitamin C, vitamin E, carotenoids), flavonoids, and vegetable protein. In terms of coronary heart disease risk reduction, vegetarian diets and high fiber have been shown to be protective in various human studies. High fiber diets appear to decrease the risk for intestinal disorders such as colon cancer, and vegetables are a rich source of folate, which may also play a role in reducing risk of cancer and cardiovascular disease. Components of vegetables and fruits are not mutually exclusive; to achieve full benefit from these foods, whole foods must be consumed rather than simply nutrient supplements.

**Recommendations for Feeding**

Clean, potable water should be available at all times. Because gorillas are selective vegetarians in nature, wherever possible whole vegetation or produce items including the stalk and peels should be fed to simulate wild conditions. There appears to be little need to feed gorillas any type of animal products, including eggs. Nursing young would receive milk. Gorillas do not consume animals products to any extent in the wild. Although they have been reported to consume a variety of insects, the overall nutritional impact appears quite limited and extremely difficult to quantify. Human dietary trials have demonstrated that primates can survive and thrive eating diets composed solely of vegetables, fruits, and nuts (Jenkins et al., 1995).

Commercial products are a readily available source of nutrition for these animals; however, no systematic comparative evaluation of these products has been conducted. More than 19 different commercial products are fed to gorillas in North American zoos. Selection of a commercial feed should be based on high vegetable fiber content (>25% ADF based on native diet) and low fat (<8% total fat, virtually no saturated fat). Using natural food composition as a basic guide, no animal or dairy products should be in the formulation of diets provided to gorillas. Unfortunately, gorilla nutrient requirement data have not been established. Until that time, it is tempting to use vitamin and mineral requirements of humans, adjusted relative to the size of the gorilla, as a guideline for diet formulation. Certainly, the diets and ingredients offered in the amounts and proportions suggested by the survey data would at least meet, and may exceed, the human dietary allowances published by the National Academy of Sciences. However, whereas these allowances can be used as a guideline, further research must be conducted in this area.

It may be suitable to feed a higher protein concentration diet to young growing animals; however, in general diets selected by gorillas in nature are not particularly high in protein. From the limited assays available in the literature, cultivated fruits are generally lower in protein and fiber and higher in moisture and simple sugars than native fruits eaten by gorillas. Vegetable
produce would, in general, appear to contain a more suitable nutrient composition than fruits for lowland gorillas and provide an economic alternative to fruit. While current diets contain fruit and vegetable produce equalling about 50% of total food offered, it is suggested that the proportion of fruit in diets be reduced, and vegetable produce increased. A general guideline for feeding adult gorillas might be to aim for a total daily quantity not to exceed 4.5% of body mass (as-fed basis) or approximately 1.25% of body mass (dry-matter basis) comprising (on an as-fed basis) 10% fruits (3-4 types), 40% vegetables (4-5 types), 25% dark green leafy produce and/or palatable browses (aim for 10% green produce, 15% browse), 23% dry high-fiber primate biscuits, and up to 2% of the total quantity as whole, cracked, or rolled grains, nuts, or seeds (the latter category fed as occupational food).

Diets offered to juvenile gorillas would follow the same general category proportions (50% produce: 15% fruit, 35% vegetable for increased palatability when introducing solid foods), 25% green leafy produce and/or browse, approximately 18% high-fiber primate biscuit, 2% cereal grains, nuts, or seeds, and up to 5% animal-based products including milk. Total amounts offered to young gorillas can be increased to approximately 6.5% of total body mass (as-fed basis). In all cases, green plant materials and/or high-fiber biscuits can be fed in relative excess, but other diet items should be limit-fed. A minimum of about 20% of the diet should comprise nutritionally balanced primate diets, with possible substitutions/variety provided throughout the week in other food categories.

While browse may supply adequate levels of some of these nutrients, availability is seasonal in many locations. Nonetheless, browse should be considered an important component of captive gorilla diets, both physiologically and psychologically. More data and improved dietary recording of browse fed must be undertaken by each zoo. With suitable browse composition data, it may be possible to reduce reliance on other dietary components through nutrient substitutions with browse, at least seasonally.

**Future Research Needs**

Much information needs to be collected in a systematic manner in order to truly evaluate diets for captive gorillas, and this should receive priority status. Detailed intake, digestion, and passage trials would provide baseline digestive physiology data with which to supplement current speculations that use humans as a model. Trials designed to compare digestibility and palatability of various commercial primate biscuits would assist in making finite product recommendations. Finally, intake data, nutrient composition, and palatability of various browses consumed by gorillas in zoos is essential to develop and provide optimal diets for this species in captivity.
gorillas are primarily folivores (Harcourt and Fossey, 1977; Watts, 1984; 1985). Their diet consists primarily of foliage of herbs and vines, with leaves making up 68% of intake, stems 25%, pith 2.5%, epithelium from roots 1.4%, and the remaining 4% from bark, roots, flowers, and fruit. The western lowland gorilla apparently consumes more fruit (Williamson, 1990; Nishihara, 1992; Tutin and Fernandez, 1993); however, green plant material remains the majority of the diet. Calvert (1985) concluded that, of the plant species consumed by western lowland gorillas in Cameroon, 23% of the species were vines, 38% herbs, 24% saplings, and 15% trees. Western lowland gorillas in Gabon consume slightly different proportions of food than do mountain gorillas, with leaves and stems accounting for twice the intake of fruit (Tutin and Fernandez, 1993). Tutin also reports that many foods consumed overlap with that of common chimpanzees occupying the same range. Gorillas seem to shift their food intake according to seasonal variations and food availability (Nishihara, 1992; Tutin and Fernandez, 1993). Calvert (1985) found no evidence of animal matter being either consumed or found in the feces. The eastern lowland gorilla diet appears to be closer to that of the western lowland gorilla than that of the mountain gorilla, but little literature exists.

Free-ranging gorillas consume a wide variety of plant species, with 50 to 300 species reported (Calvert, 1985; Rogers et al., 1990). However, they are very selective, choosing only certain parts of the vegetation at certain times of the year (Rogers and Williamson, 1987; Williamson et al., 1988). Base and tips of young leaves are eaten (i.e., Haumania liebrechtsiana and Megaphrynium gabonense); mature as well as young leaves are also eaten in some species (Milicia excelsa); and in many species, only mature leaves were consumed (Rogers et al., 1990). Aframomum seems to be an important genus to gorillas at all study locations. Even captive gorillas are selective feeders, with particular species and plant parts preferred by individuals and groups (J. Ogden, San Diego Zoo, unpublished data). Gorillas generally select immature leaves over the mature ones, which usually contain less fiber, more protein, and less secondary components such as tannins (Hladik, 1978; Milton, 1979; Rogers et al., 1990). Shoots, flowers, and fruit are also preferred over mature leaves (Clutton-Brock, 1975; Casimir, 1975). Woody vegetation species are not avoided (Calvert, 1985). Rogers et al. (1990) conducted the most complete chemical analysis of the diet of the western lowland gorilla in the Lope Reserve, Gabon. The gorillas in Lope Reserve do not appear to select food based on any anti-nutritional properties (i.e., phenolic compounds), and consume a wide variety of fruit from highly proteinaceous unripe seeds to sugary fruit. They seem to avoid unripe and higher-fat fruit. Fruits consumed by gorillas are much more fibrous than our traditional idea of cultivated fruits commercially available in the west. Thus, from a nutritive perspective, caution must be used to interpret wild dietary data based on percentages of vegetation and fruit intake. Fruit consumed by the gorilla typically can have the same or even higher levels of dietary fiber as leaves (as shown in Table 1. (Data from Calvert, 1985; Rogers et al., 1990.)

<table>
<thead>
<tr>
<th>Nutrient Composition</th>
<th>Leaves</th>
<th>Shoots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein</td>
<td>0.2 to 8.0</td>
<td>8.9 to 8.0</td>
</tr>
<tr>
<td>Crude Fat</td>
<td>21.3 to 72.6</td>
<td>9.0 to 13.8</td>
</tr>
<tr>
<td>WSC</td>
<td>16.5 to 58.0</td>
<td>2.0 to 20.9</td>
</tr>
<tr>
<td>NDF</td>
<td>50.0 to 88.510.6</td>
<td>13.1 to 62.4</td>
</tr>
<tr>
<td>ADF</td>
<td>0.6 to 13.5</td>
<td>55.1 to 82.3</td>
</tr>
</tbody>
</table>

vegetation has an extremely high fiber content, which cannot be digested in the stomach or small intestine, but must be fermented in the large intestine by gut microbes to produce short chain fatty acids (SCFA), carbon dioxide, and methane. Gorillas have an enlarged hindgut for harboring such bacteria (Stevens, 1988), and SCFAs are likely used by gorillas and even humans for energy production and colonic health. However, no metabolic studies have been conducted.
zoos (27%) offered between 11 and 15 different food items daily; 10 (27%) offered between 16 to 20 items daily; 3 zoos (8%) offered more than 20 different items daily. The remaining 14 zoos offered 10 or fewer items daily. Overall, the zoos fed an average of three meals per day, which were usually scattered in the exhibit. The majority of zoos (n=27; 73%) use commercially prepared diets in addition to produce, while 10 zoos (27%) prepare their own staple diet. Six zoos fed meat on a regular or occasional basis.

Twenty different vegetables were fed on a daily basis. The majority of zoos fed carrots (79% of the zoos), sweet potatoes/yams (71%), green beans (38%), onions (29%), white potatoes (29%), corn on the cob (12.5%), and leeks (12.5%). Twenty-three different fruits were fed on a regular basis, with the majority of zoos feeding apples (96%), bananas (89%), oranges (85%), grapes (48%), fruit juices (22%), raisins (19%), and tomatoes (11%). Twenty-five different types of greens/browse were fed, including celery (89%), lettuce (71%), spinach (54%), kale (46%), broccoli (43%), cabbage (25%), willow browse (21%), parsley (14%), escarole (14%), and cauliflower (14%). Eighteen different types of cereals/grains were fed, with a majority of zoos feeding bread (86%), sunflower seeds (79%), peanuts (57%), mixed nuts (29%), popcorn (29%), and white rice (14%). Nineteen different commercial products were fed, with the primary staple comprising Mazuri Old World Primate (fed by 32% of the zoos), Purina (Lab Diet) High Protein (20%), Marion Leaf Eater Biscuit (20%), Spectrum Primate Pro-Plus (16%), HMS High Fiber Primate (16%), Mazuri Leaf Eater (12%), Zu/Preem Primate Dry (8%), and Purina Lab Diet (8%). Animal products including meat, eggs, milk, and yogurt were fed to the gorillas with frequencies as shown in Table 2.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>61</td>
<td>50</td>
<td>Egg</td>
<td>19</td>
</tr>
<tr>
<td>Milk</td>
<td>18</td>
<td>10</td>
<td>Yogurt</td>
<td>21</td>
</tr>
</tbody>
</table>

A macronutrient profile was developed using a modified computerized USDA database with modification for dietary fiber values; this included limited preliminary analysis of some browse (Wildlife Conservation Society) and commercial primate mixtures. Evaluation of Adequacy information from the surveys described diets offered, not consumed, by captive gorillas. Adequate detail for assessing nutrient composition of offered diets was available from diets of 18 adult males, 18 adult females, and 14 juveniles. The calorie content of food items was calculated based on metabolizable energy (ME) values for humans (Watt and Merrill, 1975) or, in the case of commercial products, from energy estimations provided by manufacturers. Metabolizability of browses was estimated at 50 percent. Metabolic studies have not been published for gorillas; values for produce items based on humans may underestimate actual caloric contributions for gorillas due to the increased complexity of the gorilla hindgut. Nonetheless, these values provide some interesting speculation on diet composition. Caloric needs of the gorilla can be estimated from the general energetic equation of Kleiber (1947), where basal metabolic rate (BMR) = 70 kcal x (body mass in kg)^0.75. Adult maintenance energy would then be estimated as 2 x BMR, and growing animals 3 x BMR. Thus, for captive gorillas ranging from approximately 20 kg. (juvenile) to 220 kg. (adult male), energy needs would theoretically be met with 1990 to 8000 kcal/day. Body mass estimates used throughout this report include 150 kg. for adult male gorillas, 100 kg. for adult females, and 50 kg. for growing juvenile gorillas. Although ranges were wide (>50%), diets offered to zoo animals in this survey appeared to provide adequate energy (Table 3); some surveys noted obese animals.

Table 3. Calculated metabolized energy content of diets offered to zoo gorillas in North America, compared with theoretical requirements based on metabolic body size.

<table>
<thead>
<tr>
<th>Body Mass (kg)</th>
<th># Diets Evaluated</th>
<th>Amount offered in kg (as fed)</th>
<th>Amount offered in kg (dry)</th>
<th>Mean kcal in diet offered</th>
<th>Estimated kcal requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Male</td>
<td>150</td>
<td>17*</td>
<td>7.05</td>
<td>1936</td>
<td>610</td>
</tr>
<tr>
<td>Adult Female</td>
<td>100</td>
<td>18</td>
<td>4.17</td>
<td>560</td>
<td>4430 (2 x BMR)</td>
</tr>
<tr>
<td>Juvenile</td>
<td>50</td>
<td>14</td>
<td>3.25</td>
<td>420</td>
<td>3930 (3 x BMR)</td>
</tr>
</tbody>
</table>
Dietary amounts offered to gorillas in the survey ranged from 4.7% of body mass (adults; as-fed basis) to 6.5% for juveniles. On a dry matter basis, amounts ranged from 1.0% (adult males) to 1.3% (adult females) of body mass. Herbivorous mammals typically consume 1 to 2.5% of dry matter on a daily basis. On an as-fed basis, diets offered comprised the following ingredient categories (Table 4).

Table 4. Dietary ingredients (by category) offered to gorillas in North American zoos, expressed as percentages on an as-fed basis (results of survey, 1995).

<table>
<thead>
<tr>
<th></th>
<th>% Fruit</th>
<th>% Vegetables</th>
<th>% Greens/Browse</th>
<th>% Commercial Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>11.0</td>
<td>26.6</td>
<td>27.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Junior</td>
<td>25.3</td>
<td>27.3</td>
<td>11.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>
| Young, growth considerably depending upon the facility surveyed. The percent of fruit in the diet varied from 10% (all groups) to 51% (adult males) of food offered. Vegetables (including tubers, roots, legumes, and stalks) ranged from 6% (adult males and juveniles) to 50% (adult males) of diet, whereas dark green leafy vegetables and browse ranged from 0% (adults) to as much as 60% (males) of diet. Commercial products comprised as little as 2% of diet as offered, up to a maximum of 55%; seeds, nuts, and cereal grains equalled 0% to 17% of total diets as-fed. Animal-based products composed up to 33% of total diet offered to some juveniles. Browse types fed to gorillas in this survey are identified in Table 5. Table 5. List of browse offered to and consumed by gorillas in North American zoos (surveyed 1995).

- Acer sp maple
- Lonicera sp.
- Sunflowers, sweet potato vine
- Celtis sp hackberry
- Musa spp banana, daikon
- Vitis vinifera grape
- Diosporos sp persimmon
- Poa spp pea plants, bean plants
- Phaeoameria sp ginger
- Hemerocallis spp day lilies
- Eugenia vulgare sorghum (w/out seed heads)
- Malviscus malviscus plants
- Zea mays corn stalks
- Sambucus sp elderberry
- Quercus sp oak
- Ulmus sp elm
- Delonix sp royals

Based on amounts and ingredients in the survey. Macronutrient profile was developed using a computerized USDA database with modifications for dietary fiber values, preliminary analyses of browses (Wildlife Conservation Society), and commercial primate mixtures. Intake was not measured; nutrient profile estimates in Table 6 are based on diets provided. Table 6. Mean macronutrient profile in diets offered to gorillas in North American zoos.

| % of dry matter | % of energy provided by Moist-ure | % Moist-ure | % Crude Protein | % Crude Fat | % Crude Fat
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrate</td>
<td>Male</td>
<td>Female</td>
<td>Young, growth</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>71.9</td>
<td>16.4</td>
<td>5.8</td>
<td>14.1</td>
<td>0.69</td>
</tr>
</tbody>
</table>

One-fifth the fiber level analyzed in native foods eaten by lowland gorillas, and about twice the fat content. Digestion data were not available for zoo gorillas, but passage has been estimated at 36 to 38 hours (Milton, 1984). Diets consumed by free-ranging animals have been estimated to be no more than 50% digestible (weighted mean, individual plants ranged from 4.6% to 81.3% digestibility using a cellulose/pepsin in vitro digestion technique (Calvert, 1985). Data reported here suggest a much higher diet digestibility, and relatively unchallenged fiber fermentation capabilities. Health Risks Linked to Diet: Captive gorillas can be compared with westernized humans; they are both displaced from their natural diet and lifestyle and are thus at risk for specific diseases. Gorillas are vegetarians, consuming no animal products. This may be essential for health, as elevated cholesterol levels (281 to 311 mg/dL, McGuire et al., 1989) have been reported in zoo gorillas, leading to premature cardiovascular disease. Human subjects with the same values would be considered hypercholesterolemic and at risk for heart disease. Cardiac arrest associated with a poor diet and lack of exercise in captivity has been cited as a significant cause of adult gorilla deaths in zoos (Cousins, 1979). Gorillas on relatively low fiber diets may also be prone to ulcerative colitis, an intestinal disorder (Scott and Kemer, 1975). These intestinal disorders may be prevented by a fiber-derived short chain fatty acid, butyrate, which is
a preferred energy substrate for colonic mucosal cells and has been shown to have antineoplastic properties (Roediger, 1982; Weaver et al., 1988). Vegetables, and to some extent fruits, have many components that may play a major role in the prevention of disease, including dietary fiber, folic acid, antioxidant vitamins (vitamin C, vitamin E, carotenoids), flavonoids, and vegetable protein. In terms of coronary heart disease risk reduction, vegetarian diets and high fiber have been shown to be protective in various human studies. High fiber diets appear to decrease the risk for intestinal disorders such as colon cancer, and vegetables are a rich source of folate, which may also play a role in reducing risk of cancer and cardiovascular disease. Components of vegetables and fruits are not mutually exclusive; to achieve full benefit from these foods, whole foods must be consumed rather than simply nutrient supplements.

**Recommendations for Feeding**

Clean, potable water should be available at all times. Because gorillas are selective vegetarians in nature, wherever possible whole vegetation or produce items including the stalk and peels should be fed to simulate wild conditions. There appears to be little need to feed gorillas any type of animal products, including eggs. Nursing young would receive milk. Gorillas do not consume animal products to any extent in the wild. Although they have been reported to consume a variety of insects, the overall nutritional impact appears quite limited and extremely difficult to quantify. Human dietary trials have demonstrated that primates can survive and thrive eating diets composed solely of vegetables, fruits, and nuts (Jenkins et al., 1995). Commercial products are a readily available source of nutrition for these animals; however, no systematic comparative evaluation of these products has been conducted. More than 19 different commercial products are fed to gorillas in North American zoos. Selection of a commercial feed should be based on high vegetable fiber content (>25% ADF based on native diet) and low fat (<8% total fat, virtually no saturated fat). Using natural food composition as a basic guide, no animal or dairy products should be in the formulation of diets provided to gorillas. Unfortunately, gorilla nutrient requirement data have not been established. Until that time, it is tempting to use vitamin and mineral requirements of humans, adjusted relative to the size of the gorilla, as a guideline for diet formulation. Certainly, the diets and ingredients offered in the amounts and proportions suggested by the survey data would at least meet, and may exceed, the human dietary allowances published by the National Academy of Sciences. However, whereas these allowances can be used as a guideline, further research must be conducted in this area. It may be suitable to feed a higher protein concentration diet to young growing animals; however, in general diets selected by gorillas in nature are not particularly high in protein. From the limited assays available in the literature, cultivated fruits are generally lower in protein and fiber and higher in moisture and simple sugars than native fruits eaten by gorillas. Vegetable produce would, in general, appear to contain a more suitable nutrient composition than fruits for lowland gorillas and provide an economic alternative to fruit. While current diets contain fruit and vegetable produce equaling about 50% of total food offered, it is suggested that the proportion of fruit in diets be reduced, and vegetable produce increased. A general guideline for feeding adult gorillas might be to aim for a total daily quantity not to exceed 4.5% of body mass (as-fed basis) or approximately 1.25% of body mass (dry-matter basis) comprising (on an as-fed basis) 10% fruits (3-4 types), 40% vegetables (4-5 types), 25% dark green leafy produce and/or palatable browses (aim for 10% green produce, 15% browse), 23% dry high-fiber primate biscuits, and up to 2% of the total quantity as whole, cracked, or rolled grains, nuts, or seeds (the latter category fed as occupational food). Diets offered to juvenile gorillas would follow the same general category proportions (50% produce 15% fruit, 35% vegetable for increased palatability when introducing solid foods), 25% green leafy produce and/or browse, approximately 18% high-fiber primate biscuit, 2% cereal grains, nuts, or seeds, and up to 5%
animal-based products including milk. Total amounts offered to young gorillas can be increased to approximately 6.5% of total body mass (as-fed basis). In all cases, green plant materials and/or high-fiber biscuits can be fed in relative excess, but other diet items should be limit-fed. A minimum of about 20% of the diet should comprise nutritionally balanced primate diets, with possible substitutions/variety provided throughout the week in other food categories. While browse may supply adequate levels of some of these nutrients, availability is seasonal in many locations. Nonetheless, browse should be considered an important component of captive gorilla diets, both physiologically and psychologically. More data and improved dietary recording of browse fed must be undertaken by each zoo. With suitable browse composition data, it may be possible to reduce reliance on other dietary components through nutrient substitutions with browse, at least seasonally. **Future Research Needs**

Much information needs to be collected in a systematic manner in order to truly evaluate diets for captive gorillas, and this should receive priority status. Detailed intake, digestion, and passage trials would provide baseline digestive physiology data with which to supplement current speculations that use humans as a model. Trials designed to compare digestibility and palatability of various commercial primate biscuits would assist in making finite product recommendations. Finally, intake data, nutrient composition, and palatability of various browses consumed by gorillas in zoos is essential to develop and provide optimal diets for this species in captivity. **Product List**

<table>
<thead>
<tr>
<th>Animal Spectrum Leafeater Primate Diet</th>
<th>HMS High Fiber Primate Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Spectrum, Inc.</td>
<td>Higginbottom Management Services</td>
</tr>
<tr>
<td>P.O. Box 721</td>
<td>1222 Echo Lane</td>
</tr>
<tr>
<td>North Platte, NB 69103-0721</td>
<td>Bluffton, IN 46714</td>
</tr>
<tr>
<td>(800)228-4005; fax (308)534-7015</td>
<td>(219)824-5157</td>
</tr>
</tbody>
</table>

(product list cont.)

<table>
<thead>
<tr>
<th>Marion Primate LeafEater Diet</th>
<th>Purina Lab Diet--High Protein, and Purina Lab Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marion Zoological, Inc.</td>
<td>PMI Feeds, Inc.</td>
</tr>
<tr>
<td>113 N. First</td>
<td>Suite L-103 One Woodside</td>
</tr>
<tr>
<td>Marion, KS 66861</td>
<td>Richmond, IN 47371</td>
</tr>
<tr>
<td>(800)327-7974</td>
<td>(317)966-6660</td>
</tr>
</tbody>
</table>

| Mazuri Old World Primate and          | Zu-Preem Primate Diet Dry |
| Mazuri Leaf-Eater Primate Diet        | Premium Nutritional Products |
| PMI Feeds, Inc.                       | 5500 Southwest Seventh Street |
| P.O. Box 66812                        | Topeka, KS 66606                             |
| St. Louis, MO 63166-6812              | (800)345-4767, fax (913)273-3406               |
| (314)768-4592, fax (314)768-4859       | |

151
CLEANING AND ROUTINE MAINTENANCE

M. Bond

Cleaning and maintaining the habitats and associated areas of gorilla environments is primarily the responsibility of the keeper; how and with what those duties are performed is within the purview of the curator and veterinary staff. USDA regulations provide minimal standards for cleaning, but a team approach can customize a program for each institution that will ensure an attractive, healthy, appealing environment for apes.

OUTDOOR EXHIBITS

Many outdoor exhibits have natural substrate, which makes thorough disinfection difficult or even impossible. Spot-cleaning of fecal material and food wastes is critical to maintain a healthy and odor-free environment, reducing pathogens and pests.

INDOOR EXHIBITS

On a daily basis, bedding materials can be temporarily removed or piled in a dry corner while the more soiled areas of the enclosure are cleaned and disinfected. Bedding materials should be totally replaced and the enclosure completely disinfected as needed. (Be aware that urine or fecal samples may be contaminated by cleaning materials. Always inform laboratory or research personnel of the products used in cleaning and disinfecting.) Enclosures should be dried, by squeegee, fan, wet vacuuming, etc., before animals are returned to them. Degreasers may also be used to remove body oil buildup. (See list of disinfectants and degreasers below.) Steam-cleaning or high-pressure washing can be used periodically, provided appropriate measures are taken to protect both gorillas and staff from exposure to aerosolized fecal material, thus preventing parasitic or bacterial infection. To be an effective disinfectant, steam should be over 300 degrees Fahrenheit.

DISINFECTING

Simple hosing and scrubbing removes only visible dirt. The most serious risk to the health of animals and staff comes from microscopic contamination of a viral, bacterial, or parasitic nature. Proper use of chemical disinfectants, including protection of skin and respiratory systems of both animals and personnel, is the best defense against these unseen threats. A number of products are available, the least expensive and easiest to obtain being household bleach, also called sodium hypochlorite. Veterinary staff may have a preference for a product that will be most effective germicidally while least toxic to the gorillas. Separate sets of cleaning tools should be provided each area or group of apes, to prevent the spread of any disease or parasitic infection. If separate tools are not feasible, be sure to disinfect them between areas.
Water features, such as pools and moats, and drinking water sources should be maintained free of contamination by feces, urine, food and cleaning agents. Flushing and refilling alone is insufficient to maintain an adequate level of sanitation. The use of algicides in water features must be investigated for safety. Power and/or steam cleaning of moats and pools is recommended, if possible.

The provision of enrichment items will undoubtedly have a positive influence on the cleaning routine. While more keeper time may be spent in cleaning or replacing "toys," less time will be spent cleaning up flung or spread feces and food-smearred, dirty windows. Enrichment items should be easily disinfected or replaceable.

Not only must the animals' quarters be kept as clean and germ-free as possible, but service areas should be as well. In particular, food preparation and storage areas require a high standard of sanitation. As required by USDA, food should be stored in tightly closed and labelled containers. Special attention should be paid to pest control, because both rodents and insects carry a number of diseases to which all primates (including visitors and staff) are susceptible. Traps and other mechanical means of removal are preferable to the use of poisoned baits. If poisons must be used, keepers and veterinary staff should be familiar with symptoms of poisoning and prepared for emergency detoxification, should one of the gorillas gain access to the bait. Sprays containing a hormone that prevents the maturation of cockroaches are safe and effective when used according to directions.

Whatever program of pest control is used, it should be consistent and well-documented. Cracks, holes, and accumulations of equipment provide hiding and breeding places for pests, so the physical plant and storage areas must be maintained properly. Regular removal of waste and other organic debris is critical, and refuse cans and pick-up areas must be policed regularly.

A written protocol of cleaning procedures should be developed appropriate to the specific needs of each facility, documenting frequency, methods, and products to be used. Periodic reevaluation of this protocol is helpful in maintaining clean, healthy environments at low cost with the best materials available. Personnel should be trained in the appropriate and safe use of chemicals and equipment. Written protocols can insure safe and consistent cleaning and disinfection of habitats and associated areas.

Although cleaning products and procedures may vary from facility to facility, the goal is the same: a safe, healthy environment for animals, staff, and visitors.
LIST OF CLEANING PRODUCTS FROM SURVEY RESPONDENTS

Unfortunately, survey respondents did not specify how or for what these products are used. Please consult your animal health staff and read material safety data sheets provided by the product manufacturers before using any of the products listed below.

165-A         Oxyguard
A-33          Pinesol
A-500         Pink Velvet soap
Ajax           Q-128**
Attack-A (ZEP) Quat 64
Betadine       Quatyl D
Bleach (sodium hypochlorite)* Rocal D
Breakup        Sanox2
Buckeye blue   Simple green
Commercial degreaser (soap) Soap
Dawn detergent Spic-n-span
Dishwashing soap TBQ
EnviroCare Trend soap
Environ        Triple O
Hitor          TriQuat
Laundry detergent Unicide256 (Brun & Co)
Lime-Away (for windows) Vetocide
Lysol          Vinegar & water
Maintex        Virex
Masterkleen    Wexcide
Microquat
Mop n Glo
NDIT3

* by far most frequently mentioned
** (Franklin maintenance product)
HEALTH

HEALTH
DISEASE CONCERNS IN LOWLAND GORILLAS

T. Meehan

INTRODUCTION

A survey of the SSP institutions holding gorillas was conducted to determine current medical concerns and practices. The respondents were asked to list their "biggest disease concerns." The responses in order of greatest to least concern were:

1. Balantidiasis
2. Parasitism in general
3. Trauma
4. Salmonella/Shigella infections
5. Each of the following were listed with equal frequency:
   - diarrhea (poor stool quality)
   - arthritis/degenerative joint disease
   - viral upper respiratory infection
   - cardiovascular disease
   - gastrointestinal disease in general
   - obesity

It is clear that the major organ system of concern in gorillas is the digestive system. Fifty-six percent of all responses regarding medical concerns involved diseases of the digestive system. Gastrointestinal (GI) disease is the most frequent cause of nonhuman primate morbidity (Paul-Murphy, 1993). Over the past several decades, GI disease has decreased as a cause of mortality. A review of gorilla mortality published in 1980 showed that GI disease accounted for 31 percent of the deaths in all age classes (Benirschke and Adams, 1980). A review of mortality in SSP collections from 1980 to 1994 showed mortality from GI disease accounted for 13 percent of all mortality (Meehan and Lowenstein, 1994). This difference may be due to improved prevention and treatment of GI disease or improved survivorship to older age, where GI related mortality or morbidity is less common. The difference between hand-reared and mother-reared infants may also be a factor, because enteritis is commonly reported in hand-reared infants, and there has been a trend in the past two decades towards an increase in the percentage of infants that are mother reared. The increase in mother rearing in group situations may also be responsible, however, for the high mortality due to trauma (60 percent) in infants aged one month to one year in the 1980 to 1994 period. Disease trends in infants, depending on rearing style, is a subject that requires further study.

GASTROINTESTINAL ILLNESS

Balantidium coli is a ciliate protozoan that is widely prevalent in great ape colonies (Swenson, 1993). It was the most commonly noted parasite diagnosed in gorillas, according to a survey of SSP institutions. The two stages of the life-cycle of B. coli are the trophozoite and the
cyst. The trophozoite normally exists as a free-living commensal in the large intestine. The cyst stage is the more environmentally resistant form (Teare and Loomis, 1982). Ingestion of trophozoites or cysts may lead to infection. It is unclear whether *B. coli* can invade intact mucosa (Swenson, 1993). The number of reports in gorillas, including some where other primary pathogens were not identified, suggest that it can cause primary disease, including invasive colitis. *B. coli* can also be a secondary invader in animals with GI lesions from other causes. A classification of the types of infection with *Balantidium* has been suggested (Lee and Prowten, 1990).

1. Asymptomatic carriage or commensalism (most common condition)
2. Mucosal or superficial infection (most common clinical disease)
   a. Diarrheal syndrome: mucosal inflammation/irritation with frequent, mucous, semiliquid stools
   b. Dysentery: erosive mucositis with rectal urgency, blood, and mucus.
3. Invasive enterocolitis: extension beyond the mucosa (rare)
   a. Ulceration
   b. Abscess formation
   c. Perforation with local and metastatic spread (typhlitis)

Stress may also be a factor in the pathogenesis of the disease (Teare and Loomis, 1982). The author has seen explosive diarrhea due to *Balantidium* in a gorilla that was receiving multiple antimicrobial agents and an immune-suppressive drug. There have also been reports to the SSP of *Balantidium* outbreaks in animals that were introduced to new collections without complete quarantine and screening for *Balantidium*.

It is recommended that animals coming from collections where *B. coli* is endemic be treated prophylactically for a course that includes the pre- and post-shipment period. This treatment should be in addition to the usual pre-shipment and quarantine parasite exams and serves as a precaution in case the parasite is inapparent and shipping stress might cause clinical disease.

Clinical disease caused by *Balantidium* may be self-limiting or resolve with treatment of other pathogens. Diarrhea from other causes may contain large numbers of motile trophozoites, because liquid stool is probably a more hospitable environment than formed stool (Swenson, 1993). The disease may progress rapidly in the gorilla, however, and it is important that appropriate diagnostic tests and treatment with antipROTOzoal agents are instituted promptly in the case of diarrhea that is watery or contains any blood or mucus. Bacterial cultures should be done in addition to fecal flotation and wet mounts of direct stool samples. Bacterial pathogens such as *Salmonella*, *Shigella*, *Campylobacter sp.*, enterotoxogenic *E. coli* and *Yersinia spp.* are all potential pathogens that need to be identified and treated appropriately. Animals that show signs of abdominal pain in addition to bloody stool should be immobilized and examined for any signs consistent with bowel penetration. A number of cases of bowel perforation requiring surgical resection have been reported (Lee and Prowten, 1990; Lee et al., 1990; Mainka, 1990), and prompt action in these cases is essential.

The following treatments have been reported for *Balantidium* (Teare and Loomis, 1982; Swenson, 1993) and are included in Table 1 as recommendations. Gorillas may for a number of
reasons remain positive following treatment. Treatment should be accompanied by thorough
disinfection, as well as treatment of any other animals that may serve as a source of organisms to
the gorillas. Any animal with severe diarrhea should also receive supportive treatment, including
fluid and electrolyte replacement.

Table 1.

<table>
<thead>
<tr>
<th>DRUG</th>
<th>DOSAGE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetracycline</td>
<td>15 gm/kg tid (infants and</td>
<td>May act on B. coli by affecting the bacteria on which they</td>
</tr>
<tr>
<td></td>
<td>juveniles)</td>
<td>feed</td>
</tr>
<tr>
<td></td>
<td>500 to 1000 mg tid (adults)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 to 14 days</td>
<td></td>
</tr>
<tr>
<td>Metronidazole (Flagyl)</td>
<td>12 to 15 mg/kg tid (infants</td>
<td>Probably the best drug but poorly accepted due to bitter</td>
</tr>
<tr>
<td></td>
<td>and juveniles)</td>
<td>taste. Acts systemically as well as in the intestine.</td>
</tr>
<tr>
<td></td>
<td>750 mg tid (adults)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 to 10 days</td>
<td></td>
</tr>
<tr>
<td>Benzoyl Metronidazole</td>
<td>Mg. dose is 1.6 times that of</td>
<td>Available through some compounding pharmacies. Much better</td>
</tr>
<tr>
<td>chemical grade</td>
<td>Metronidazole due to the</td>
<td>accepted than metronidazole due to taste.</td>
</tr>
<tr>
<td></td>
<td>molecular weight of the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>benzoyl group</td>
<td></td>
</tr>
<tr>
<td>Iodoquinol (Yodoxin)</td>
<td>12 to 16 mg/kg tid (infants</td>
<td>Minimally absorbed and acts only in the lumen of the bowel.</td>
</tr>
<tr>
<td></td>
<td>and juveniles)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>650 mg tid (adults)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 to 21 days</td>
<td></td>
</tr>
<tr>
<td>Paromomycin (Humatin)</td>
<td>10 mg/kg tid</td>
<td>Poorly absorbed from intestine. Use only in non-invasive</td>
</tr>
<tr>
<td></td>
<td>5 to 10 days</td>
<td>disease.</td>
</tr>
</tbody>
</table>

Pathogenic amoeba are occasionally to routinely diagnosed in SSP institutions. *Entamoeba histolytica* is the most commonly diagnosed pathogenic amoeba. The clinical signs may range from inapparent infection to acute dysentery with bowel perforation and liver abscesses.

It may be difficult to distinguish *E. histolytica* from common nonpathogenic amoeba such as *E. hartmanni* and *Entamoeba coli*. Fresh stool samples prepared as wet mounts and trichrome-stained within 30 minutes may reveal trophozoites. Normal direct samples or formalin-ether concentrated stools can be stained with iodine to assist in identification of nuclear characteristics. Identification of three consecutive samples increases the sensitivity of stool samples to 60 to 70 percent, compared with 33 percent for a single sample (Swenson, 1993). Technicians unfamiliar with the characteristics of the various amoeba should refer samples to qualified labs or consult texts for identification characteristics and photographs of various
species.

Paromomycin at the above dose is recommended. Invasive cases must be treated with a drug that is absorbed, such as metronidazole, also at the above dose, followed by a course of Iodoquinol.

*Giardia lamblia* is diagnosed occasionally in gorillas at SSP institutions. It may be under-recognized: finding trophozoites in stool is difficult because of the small intestinal location of the parasite or because the infection is rarely of significance (Swenson, 1993). It can produce watery diarrhea and should be ruled out when no other cause for diarrhea is found. Diagnosis is by finding cysts on fresh, iodine-stained wet mounts of stools or trichrome-stained smears. Furazolidone at a dose of 100 mg qid for adults and 5 mg/kg qid for juveniles for 7 days is recommended (Swenson, 1993).

The most commonly diagnosed parasite in SSP institutions other than those previously mentioned is *Strongyloides stercoralis*. It is diagnosed occasionally to routinely and was not mentioned specifically as a medical concern by any of the respondents. The frequency and severity of clinical signs with *Strongyloides* is reported to be less in gorillas than in orangutans (Munson and Montali, 1990). It has been reported as a cause of mortality (Benirschke and Adams, 1980) and is certainly a potential pathogen, especially in mixed infections. Thiabendazole (Mintezol) appears to be effective if taken orally at the recommended human dose. This product comes as both a pediatric, flavored suspension and as flavored chewable tablets, making it more acceptable. Ivermectin at 0.2 mg/kg daily orally for three consecutive days also appears effective. The variety of treatments and dosages reported in a survey of SSP institutions indicates that a more detailed study of anthelmintic treatments is warranted.

Bacterial enteritis is an important cause of morbidity and mortality in gorillas (Benirschke, 1983; Hruban et al., 1986; Munson and Montali, 1990; Janssen, 1993; Paul-Murphy, 1993), and *Salmonella/Shigella* infections were specifically noted as a disease of concern for gorillas by SSP institutions. Shigellosis is only found in humans and nonhuman primates (Banish et al., 1993; Paul-Murphy, 1993; Stetter et al., 1995) and is the most commonly reported bacterial enteric pathogen isolated from nonhuman primates (Stetter et al., 1995). *Shigella* is spread by fecal-oral transmission from infected individuals and is a zoonotic disease concern. It is an invasive bacteria that can cause an acute inflammatory reaction of the intestinal tract, with resultant diarrhea ranging to severe diarrhea with blood and mucus (Paul-Murphy, 1993). Shigellosis may be an important cause of morbidity in young animals recently introduced to collections that contain an inapparent carrier (Stetter et al., 1995). Gorillas may be less susceptible according to a report of an enzootic in a collection of zoo primates (Banish et al., 1993). Stress or concurrent enteric infections may increase susceptibility. Systemic treatment with antibiotics as indicated by sensitivity testing and supportive treatment for fluid and electrolyte loss is indicated.

*Salmonella* spp. bacteria have worldwide distribution and can infect a variety of hosts, including humans and nonhuman primates. *Salmonellae* can survive and multiply outside the host but most transmission among nonhuman primates is thought to be fecal-oral (Paul-Murphy, 1993). The bacteria can cause inapparent infection, diarrhea similar to that seen with *Shigella* or infections in other systems, including the reproductive tract. The disease is reported more frequently from zoological collections than laboratory primate colonies (Paul-Murphy, 1993).
Salmonella and Shigella are difficult to isolate during the recovery phase of disease and very difficult to isolate in inapparent carriers. Swabs should be taken from fresh feces and applied to plates or enrichment media immediately. Multiple day sampling will increase the possibility of recovery of enteric pathogens due to intermittent shedding of organisms. It is very important that cultures for Salmonella, Shigella, and Campylobacter be taken during routine health screening and pre-shipment and quarantine exams. This information in conjunction with diagnostic tests run during the course of any gastrointestinal disease will give the clinician a history of the pathogens that may be carried within a collection. Sharing this information prior to planned moves or introductions will help to anticipate problems, so that appropriate prophylactic or therapeutic treatment may be administered.

Poor stool quality and gastrointestinal disease in general were items of medical concern to SSP institutions. Infectious and parasitic agents, as mentioned above, are a very important cause of gastrointestinal illness. Due to the importance of inapparent carriers in the majority of these conditions, it is vital that routine and diagnostic testing be done in all gorilla collections to identify potential pathogens that exist in the group as a whole. Changes in social situation, diet, moves within a collection, and moves between collections all have the potential for triggering disease. Diseases that are endemic within a group should be anticipated as potential causes of clinical illness, even if infection is inapparent in individuals at the time they are moved. The treatment of asymptomatic carriers is controversial in human medicine because of the difficulty in eliminating some enteric pathogens and the subsequent development of antibiotic-resistant bacteria. Diet may be an important factor affecting stool quality and is an area that may need further study.

**TRAUMATIC INJURY**

Gorillas housed in groups may inflict traumatic injury on others or suffer accidental injury. Bite wounds are common and can range from minor to severe. Fractures, particularly in juveniles, have been reported (Benirschke and Adams, 1980). In a study of infant mortality during the period from 1980 to 1994, 60 percent of the infant deaths were the result of trauma (Meehan and Lowenstine, 1994). The treatment is generally straightforward, depending on the type of injury. Routine treatment of simple bite wounds with systemic antibiotics was not shown to be of value in orangutans (Wells et al., 1990) and the author's clinical impression is that gorilla wounds do not benefit from routine treatment with antibiotics either. A systematic study of causes of conspecific aggression in gorillas in various age and social classes would be valuable in determining how to prevent traumatic injuries.

**CARDIOVASCULAR DISEASE**

Cardiovascular disease is the cause of 41 percent of all mortality in adult and older adult gorillas (age 7 and older in females, age 9 and older in males) (Meehan and Lowenstine, 1994). It is noted as a clinical concern but is most often seen as sudden death without previously recognized clinical disease (Allchurch, 1993). The majority of deaths due to cardiac disease are caused by two syndromes: fibrosing cardiomyopathy (Schulman et al., 1995) and aortic
dissection (Hruban et al., 1986; Allchurch, 1993; Kenny et al., 1994). Both diseases occur predominately but not exclusively in males. They both occur with increasing frequency in the older age groups.

A variety of factors known to increase the risk of cardiovascular disease in humans have been mentioned as potential causes of the problems in gorillas. Cardiomyopathy may be caused by viral infection, hypertension, arteriosclerosis, obesity, stress, and other infectious or toxic agents (Schulman et al., 1995). The major risk factor in aortic dissection in humans is hypertension, seen in 58 to 90 percent of cases (Kenny et al., 1994). No studies of blood pressure in unanesthetized gorillas have been done. The largest published record of blood pressures was done with animals under phencyclidine anesthesia (Maschgan, 1981). Five of the nine animals measured had systolic, diastolic, or both pressures greater than the 140/90 mmHg recommended as the upper limit of blood pressure in humans (Kenny et al., 1994). Obesity, stress, and hypercholesterolemia are also common in association with aortic dissection in humans (Allchurch, 1993). SSP institutions consider obesity in gorillas to be a medical concern. Captive gorillas have been shown to have high serum cholesterol levels compared with humans. A mean value of 281.2 ± 88.4 mg/dl was reported in a study of 59 captive gorillas. This level would be considered high enough to require treatment in humans (Kenny et al., 1994), but the significance in gorillas is unknown. No comparisons of gorillas in the wild are available.

Factors that may predispose gorillas to cardiac disease must be studied. Blood pressure measurements by standard techniques must be taken to determine normal values. This must be correlated with pressures in unanesthetized animals as well. Older gorillas may need more in-depth cardiovascular system exams to determine the presence of cardiovascular disease. Cardiac hypertrophy may be identified with ECG or ultrasound. A case of coronary artery disease was diagnosed in vivo in a 29-year-old male gorilla (Scott et al., 1995). Further studies of serum cholesterol and lipids must be done to determine the reason for the apparent hypercholesterolemia in gorillas compared with other great apes. The effect of diet on obesity and serum cholesterol levels needs to be determined.

**ARTHRITIS**

Arthritis has been reported in gorillas due to a number of causes, including *Mycoplasma*-associated rheumatoid arthritis, ankylosing spondylitis, Legg-Calve-Perthe disease, osteoarthritis, and reactive arthritis (Brown et al., 1980; Douglas, 1981; Adams et al., 1986; Raphael et al., 1995). *Mycoplasma*-associated arthritis in one collection of great apes was unique to gorillas (Munson and Montali, 1990). The affected animals were also positive for rheumatoid factor. Antibodies to six different species of Mycoplasma were identified in this collection and *M. salivarium* was isolated from one severely affected gorilla. These gorillas responded clinically to prolonged low-dose treatment with tetracycline. Legg-Calve-Perthes disease was reported in a single individual (Douglas, 1981). The disease causes avascular necrosis of the head of the femur. The cause is unknown.

Reactive arthritis refers to acute joint inflammation following enteric or urogenital infections. This condition is closely associated with the presence of the major histocompatibility antigen HLA-B27. In humans, almost 96 percent of the Caucasian human ankylosing spondylitis
patients express this gene, while only 7 percent of the population express the gene (Brewerton et al., 1973; Schlosstein et al., 1973; Tiwari and Terasaki, 1985). Reactive arthritis is mainly seen following infection with several enteric pathogens, including *Shigella*, *Yersinia*, *Campylobacter*, and *Clostridium difficile*. Ankylosing spondylitis (Adams et al., 1986) and reactive arthritis secondary to *Shigella* infection (Raphael et al., 1995) have been seen in gorillas associated with HLA-B27 cross reactivity. The prevalence of a HLA-B27-like allele in gorillas is not known. Because there is a significant amount of enteric disease reported in gorillas, it is important to determine the prevalence of this allele in the population. Studies need to be undertaken to determine the prevalence and causes of arthritis in the gorilla population.

**UPPER RESPIRATORY INFECTIONS**

Upper respiratory infections (URIs) are common in human children. Studies have supported the opinion among pediatricians that "a child will have 100 URIs in their first ten years" (Cho and Dudding, 1978). Secondary bacterial infections including pneumonia can occur. These do not appear to be a significant cause of mortality in the gorilla. There was only one death reported in a gorilla due to respiratory infection in a review of SSP gorilla mortality for the 1980-1994 period (Meehan and Lowenstine, 1994). This was due to viral pneumonia in an infant. Upper respiratory viruses can be transmitted from humans to gorillas and vice versa. Direct respiratory aerosols and droplets present on objects can transmit disease. Contact with a large number of keepers, very close contact as in a nursery situation, and contact with keepers that have young children all increase the likelihood of upper respiratory infections in gorillas. Keepers that have active upper respiratory infections should not work in close contact with gorillas or prepare food for them. Hand washing is essential to prevent the transmission of virus from human sources into a facility via keepers' hands.
CAUSES OF MORTALITY IN CAPTIVE LOWLAND GORILLAS: A SURVEY OF THE SSP POPULATION

T. Meehan, L. Lowenstein

INTRODUCTION

Necropsy reports were requested for all western lowland gorillas (Gorilla gorilla gorilla) listed in the North American Regional Studbook that died after 1980. This period covers the years since the last published review of captive gorilla mortality (Benirschke and Adams, 1980). Records were received from 74 gorilla mortalities and divided into age classes. The most significant pathologic finding, or cause of death, was noted for each animal by sex.

RESULTS

1. Premature, abortions, stillbirths, and perinatal (one day old or less): 12 records (16.2 percent), for a total of 7 males and 5 females.

   Total deaths: 7.5

   Infection related (ascending reproductive tract infections, and placentitis): 2.4

   Dystocia: 3.0

   Intrauterine hypoxia: 1.1

   Premature (Hyaline membrane disease): 1.0

2. Neonates (one day to one month): 5 records (6.8 percent), for a total of 2 males and 3 females.

   Total deaths: 2.3

   Maternal neglect: 1.2

   Infection related (generalized bacterial): 1.0

   Congenital: 0.1
3. Infants (one month to one year): 10 records (13.5 percent), for a total of 5 males, 5 females.

Total deaths: 5.5

Trauma: 4.2

Gastrointestinal infection (bacterial): 1.1

Viral disease (respiratory): 0.1

Amebiasis (cerebral): 0.1

4. Juvenile (one year to seven years in females and one year to nine years in males): 8 records (10.8 percent), for a total of 4 males, 4 females.

Total deaths: 4.4

Gastrointestinal disease
- parasitic: 2.1
- bacterial: 1.0
- mixed bacterial and parasitic: 1.0

Cagemate inflicted trauma: 0.1

Systemic infection: 0.1

Idiosyncratic drug reaction: 0.1

5. Adults (7 to 30 years in females and 9 to 30 years in males): 22 records (29.7 percent), for a total of 12 males, 10 females.

Total deaths: 12.10

Gastrointestinal disease
- parasitic: 2.2
- bacterial: 1.2
- other (ruptured appendix): 1.0

Cardiovascular disease
- myocardial fibrosis: 2.0
- aortic dissection: 0.1
- cardiac infection related: 2.1
- other cardiovascular: 1.0

Trauma: 1.1
Periparturient death: 0.1
Neoplasia: 1.0
Infection related (suppurative meningitis): 1.0
Parasitic (hydatid disease): 0.1
Idiosyncratic drug reaction: 0.1

6. Older adults (greater than thirty years): 17 records (23 percent), for a total of 10 males, 7 females.

Total deaths: 10.7

Cardiovascular disease
myocardial fibrosis: 2.0
aortic dissection: 3.1
cardiac infection related: 1.0
other cardiovascular: 1.1

Infection related (peritonitis, urinary tract, and CNS): 1.2
Neoplasia: 0.1
Parasitic (hydatid disease): 0.1
Anesthetic related death 0.1
Euthanasia (severe osteoarthritis): 1.0
Post operative hemorrhage: 1.0

DISCUSSION

An effort was made in reviewing the necropsy reports to determine the most significant pathologic finding leading to death. There were many cases that had multiple organ system involvement, making this determination difficult. These other potentially non-fatal causes of morbidity should be the subject of further study. However, there are some findings of note in this survey. The incidence of cardiovascular disease in adults (41 percent of all deaths in adults and older adults) should prompt further investigation for known cardiovascular disease risk factors. The incidence of traumatic death in infants (60 percent of infant deaths) may also warrant a review of husbandry in group rearing situations.
Following the death or euthanasia of any gorilla, including fetuses and stillborn infants, the Great Ape TAG requests that a complete post mortem examination (necropsy) be performed by a veterinarian or a veterinary or medical pathologist. Complete histopathology should be performed. The attached forms serve as a guideline to ensure completeness and include special examinations to enhance our understanding of specific disease conditions affecting great apes (e.g., heart disease and air sac infections). The gross report and samples may be sent to the TAG pathologist for histopathology, or histopathology may be performed by the institution's pathologist. In the latter case, please send a completed report to the SSP Veterinary Advisor and the TAG pathologist. The TAG pathologist is:

Dr. Linda Lowenstine  
Pathology Service, Veterinary Medical Teaching Hospital  
University of California  
Davis, California 95616  
Phone: (916) 752-1182  
Fax: (916) 752-3349  
e-mail: ljlowenstine@vmth.ucdavis.edu

**Collection of Tissues**

Tissues should be fixed in 10 percent, neutral buffered formalin and should be less than 0.5 cm thick to allow for adequate penetration of formalin for fixation. Initial fixation should be in a volume of fixative 10 times the volume of the tissues. Agitation of the tissues during the first 24 hrs is helpful to prevent pieces from sticking together and inhibiting fixation.

**Labeling of Specimens**

If pieces are small or not readily recognizable (e.g. individual lymph nodes), they can be fixed in cassettes or embedding bags or wrapped in tissue paper labeled with pencil or indelible ink. Another alternative is to submit lymph nodes with attached identifiable tissue, e.g. axillary with brachial plexus, inguinal with skin, bronchial with bronchus, etc.

Sections from hollow viscera or skin can be stretched flat on paper (serosal side down) and allowed to adhere momentarily before being placed in formalin with the piece of paper. The paper can be labeled, before fixation, with the location from which the tissue came (use #2 pencil).

The formalin container should be labeled with the animal's name or number, the age and sex, the date and location, and the name of the prosector.
Tissues to be preserved

From the skin, submit at least one piece without lesions, a nipple and mammary gland tissue, scent gland, and any lesions and subcutaneous or ectoparasites. Axillary and or inguinal lymph nodes may be submitted whole from small animals and should be sectioned transversely through the hilus in large primates.

Mandibular and/or parotid salivary glands should be sectioned to include lymph node with the former and ear canal with the latter. Thyroids, if it is a small primate, may be left attached to the larynx and submitted with the base of tongue, pharynx, esophagus as a block. In larger primates, take sections transversely through the thyroids trying to incorporate the parathyroids in the section.

Trachea and esophagus and laryngeal air sac sections may be submitted as a block. Cervical lymph nodes may be submitted whole if small or sectioned transversely. A single sternebra should be preserved as a source of bone marrow. A marrow touch imprint may be made from the cut sternebra and air dried for marrow cytology.

Section of thymus or anterior pericardium should be taken perpendicular to the front of the heart.

Heart: Weigh and measure heart after opening and removal of postmortem clots but before sectioning (see following cardiac protocol for apes). Fix longitudinal sections of left and right ventricles with attached valves and atria in large animals and the whole heart opened and cleaned of blood clots in smaller animals. In tiny animals, the heart may be fixed whole after cutting the tip off the apex.

Lungs: If possible, inflate at least one lobe by instilling clean buffered formalin into the bronchus under slight pressure. Fix sections from at least one lobe from each side and preferably samples from all lobes. In little animals, the entire "pluck" may be fixed after perfusion.

Take sections of all levels of the GI track, including: gastric cardia, fundus and pylorus; duodenum at the level of the bile duct with pancreas attached; anterior, middle and distal jejunum; ileum; ileoceccolic junction with attached nodes; cecum and (in apes) appendix; ascending, transverse and descending colon. Open loops of bowel to allow exposure of the mucosa and allow serosa to adhere momentarily to a piece of paper before placing both bowel section and paper in formalin, or gently inject formalin into closed loops.

Liver: One section should include bile ducts and gall bladder; take sections from at least one other lobe.

Make sure sections of spleen are very thin if the spleen is congested; formalin does not penetrate as far in very bloody tissues.

Mesenteric (jejunal) nodes should be sectioned transversely; colonic nodes may be left with colon sections.

Take sections from each kidney: cut the left one longitudinally and the right one
transversely so the side can be identified.

Fix small adrenals whole and section larger ones (left-longitudinal and right transversely) making sure to use a very sharp knife or new scalpel blade so as not to squash these very soft glands.

Bladder sections should include fundus and trigone. Make sure to include round ligaments (umbilical arteries) in neonates.

Section the prostate with the urethra and seminal vesicles transversely. Section testes transversely, and include epididymus, vas deferens, and pampiniform plexus.

In small females, fix the vulva, vagina, cervix, uterus, and ovaries as a block after making a longitudinal slit to allow penetration of formalin. Rectum and bladder (opened) can also be included in this block. In somewhat larger animals, make a longitudinal section through the entire track. In large primates, make transverse sections of each part of the track and the ovaries.

If gravid: weigh and measure placenta and fetus. Perform a post mortem examination of the fetus. Take sections of disc from periphery and center and from extra-placental fetal membranes. Take sections of major organs and tissues of fetus.

The brain should be fixed whole, or, if too large for containers, may be cut in half longitudinally (preferred) or transversely through the midbrain. It should be allowed to fix for at least a week before sectioning transversely (coronally) into 0.5-1.0 cm slabs to look for lesions. Submit the entire brain if possible and let the pathologist do the sectioning, otherwise submit slabs from medulla, pons and cerebellum, midbrain, thalamus and hypothalamus, prefrontal, frontal, parietal, and occipital cortex, including hippocampus and lateral ventricles with choroid plexus.

Fix the pituitary whole. Put pituitary in an embedding bag if it is small. Also remove and fix the Gasserian (trigeminal) ganglia.

Spinal chord: If clinical signs warrant, remove the cord intact and preserve it whole or in anatomic segments (e.g., cervical, anterior thoracic etc.).

Take bone marrow by splitting or sawing across the femur, to get a cylinder and then make parallel longitudinal cuts to the marrow. Try to fix complete cross sections or hemisections of the marrow. Imprints can also be made.

Take sections of any and all lesions, putting them in embedding bags if they need special labeling.

Remember, it's better to save "too many" tissues than to risk missing essential lesions or details. This represents a lot of work on the part of the prosector, often under less than comfortable conditions. But the effort expended at the time of the gross post mortem is much appreciated by the histopathologist, and is crucial to our investigations of the causes of morbidity and mortality of great apes and other nonhuman primates.
THANK YOU !!!!!
STANDARDIZED NECROPSY REPORT FOR GREAT APES AND OTHER PRIMATES
WORK SHEET

Pathology # _____________ Species _______________________ Date _____________
Animal #/Name ___________________ Sex _______ Age (DOB) _____________
Date of Death/Euthanasia _____________ Time ____________ (am/pm)
Method of euthanasia _____________________
Time and date of necropsy _____________ Duration of necropsy _____________
Post mortem state _________________ Nutritional state __________________
Pathologist or prosector/ institution:______________________________________

Gross diagnoses:

Abstract of clinical history: (please attach a copy of medical record, if possible)

Please check tissues submitted for histopathology.

External Examination (note trauma, parasites, exudates, diarrhea):
   Hair coat:
   ___Skin and subcutis (check hydration):
   ___Scent glands:
   ___Mammary glands and nipples:
   ___Umbilicus (see neonatal/fetal protocol):
   ___Subcutis (note: fat, edema, hemorrhage, parasites):
      Mucous membranes (note: color, exudates):
      Ocular or nasal exudate?:
   ___Eyes and ears:
   ___External genitalia:
   ___Oral cavity, cheek pouches, pharynx, tonsils:
      Dentition (see attached dental form):
   ___Tongue:

Musculoskeletal System:
   Fractures or malformations?:
   ___Muscles:
Bone marrow (femur):
Joints (check round ligaments of femoral head):
Spinal column (examine ventral aspect when viscera removed)

Examination of the neck region:
Larynx:
Laryngeal air sac (see protocol for great apes):
Mandibular and parotid salivary glands:
Thyroids and parathyroids:
Cervical/cranial lymph nodes:
Esophagus:

Thoracic Cavity:
Effusions, adhesions, or hemorrhage?:
Mediastinal and coronary fat:
Thymus:
Heart (see attached protocol):
Great vessels:
Trachea and bronchi:
Lungs:

Esophagus:
Lymph nodes:

Abdominal Cavity:
Effusions, adhesions, or hemorrhage?:
Omental, mesenteric and perirenal fat:
Liver:
Stomach:
Pancreas:
Duodenum:
Jejunum:
Ileum:
Cecum and (in apes) appendix:
Colon and rectum:
Lymph nodes:
Kidneys and ureters:
Adrenals:
Gonads:
Uterus:
Bladder and urethra:
Male accessory sex glands (prostate and seminal vesicles):
Umbilical vessels, round ligaments of bladder in neonates:
Abdominal aorta, caudal vena cava, iliac vessels:

Nervous System:
Meninges:
Brain:
Pituitary:
Gasserian ganglia:
Spinal cord:
Brachial plexus and sciatic nerves:
WEIGHTS AND MEASUREMENTS (in grams, kilograms, and cm, please):

Body weight:__________________________Kg.

Lymphoid tissue:
R. axillary LN_____________ L ax LN_____________
R. inguinal LN_____________ L inguinal LN_____________
Jejunal LN_____________
Spleen_____________
Thymus_____________

Abdominal Organs:
Liver_____________
R. kidney_____________ L. kidney_____________
R. adrenal_____________ L. adrenal_____________
R. ovary_____________ L. ovary_____________
uterus_____________

placenta (weigh and measure disc(s)):

Thoracic Organs (thymus is above under lymphoid):
Heart wt_____________ Length_____________
Circumference _____________ Left Vent._____________
Rt. vent.___________ Septum_____________
Lt. AV valve_________ Rt. AV valve_________
Aortic valve________ Pulmonary v._________
R. lung _______________ L. lung _______________

Other:
Brain_____________ Tumors? _______________
R. testes (wt.)_____________ L. Testes _______________
Length x dia._____________
Penis (length x diameter) __________________________
<table>
<thead>
<tr>
<th>Measurement Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>crown rump length (linear)</td>
</tr>
<tr>
<td>crown rump length (curvalinear)</td>
</tr>
<tr>
<td>cranial circumference (above brow ridge)</td>
</tr>
<tr>
<td>Length of head (tip of jaw to top of crest)</td>
</tr>
<tr>
<td>width of brow ridge</td>
</tr>
<tr>
<td>chest circumference (at nipples)</td>
</tr>
<tr>
<td>abdominal circumference (at umbilicus)</td>
</tr>
<tr>
<td>Left arm: Shoulder-elbow:</td>
</tr>
<tr>
<td>elbow-wrist:</td>
</tr>
<tr>
<td>wrist-tip of middle finger:</td>
</tr>
<tr>
<td>pollex:</td>
</tr>
<tr>
<td>Right arm: Shoulder elbow:</td>
</tr>
<tr>
<td>elbow-wrist:</td>
</tr>
<tr>
<td>wrist-tip of middle finger:</td>
</tr>
<tr>
<td>pollex:</td>
</tr>
<tr>
<td>Left leg: hip-knee:</td>
</tr>
<tr>
<td>knee-ankle:</td>
</tr>
<tr>
<td>ankle-tip of big toe:</td>
</tr>
<tr>
<td>heel-tip of big toe:</td>
</tr>
<tr>
<td>hallux:</td>
</tr>
<tr>
<td>Right leg: hip-knee:</td>
</tr>
<tr>
<td>knee-ankle:</td>
</tr>
<tr>
<td>ankle-tip of big toe:</td>
</tr>
<tr>
<td>heel-tip of big toe:</td>
</tr>
<tr>
<td>hallux:</td>
</tr>
</tbody>
</table>
ANCILLARY DIAGNOSTICS (CHECK IF PERFORMED, GIVE RESULTS IF AVAILABLE, NOTE LOCATION IF STORED, OR TO WHOM SENT):

Cultures:
  bacterial:
  fungal:
  viral:
Heart blood:
  serum:
  filter paper blot:
Parasitology:
  feces:
  direct smears:
  parasites:

Tissues fixed in 10% formalin (list tissues or specific lesions other than those checked above):

Tissue fixed for EM:______________  Tissue frozen:_______

Impression smears:____________________________________________

Comments (interpretation of gross findings):
CARDIAC EXAMINATION FOR GREAT APES
(AND OTHER PRIMATES IN WHICH CARDIAC DISEASE IS PRESENT)

Examine heart in situ. Check for position, pericardial effusions or adhesions. Collect for culture or fluid analysis if effusion is present. Remove heart and entire thoracic aorta with "pluck". Examine heart again. Check the ligamentum (ductus) arteriosus for patency. Check position of great vessels. Open pulmonary arteries to check for thrombi.

Remove heart and thoracic aorta from the rest of the "pluck". Examine for presence of coronary fat. Examine external surfaces, especially coronary vessels. Note relative filling of atria and state of contracture (diastole or systole at death) and general morphology. (The apex should be fairly sharp.) Measure length from apex to top of atria. Measure circumference at base of atria.

Open the heart: Begin at the tip of the right auricle and open the atrium parallel to the coronary groove continuing into the vena cava. Remove blood clot and examine the AV valves. Cut into the right ventricle following the caudal aspect of the septum and continuing around the apex to the anterior side and out the pulmonary artery. Remove postmortem clots and examine inner surface.

Open left atrium, beginning at the auricle and continuing out the pulmonary vein. Remove any clots and examine valves. Open the left ventricle, starting on the caudal aspect and following the septum as for the right ventricle. When you reach the anterior aspect, clear the lumen of blood and identify the aortic outflow. Continue the incision around the front of the heart and into the aorta, taking care to cut between the pulmonary artery and the atrium. Open the entire length of the thoracic aorta.

Remove all postmortem clots. You may gently wash the heart in cool water or dilute formalin to better visualize the internal structures and valves. Sever the thoracic aorta from the heart just behind the brachiocephalic arteries. Examine intima and adventitia and section aorta for formalin. Sever the pulmonary vessel and vena cava close to the heart. Weigh the heart and record. Measure thickness of right and left ventricles and septum. Measure the right and left AV valves and the aortic and pulmonary valves.

Take sections for histopathology. Sections should include: longitudinal sections of left and right ventricles AV valves and atria; sections of myocardium from left and right ventricles including coronary vessels; sections of papillary muscles; sections from the septum at the vaso of the AV valves (area of conduction system).

Fix the entire heart, if possible, by immersion in 10 percent buffered formalin for more detailed examination by a cardiac pathologist.

Other vessels: Make sure to examine the abdominal aorta, iliac arteries, and popliteal arteries (frequent sites of aneurysms in humans).
POSTMORTEM EXAMINATION OF
PRIMATE FETUSES AND NEONATES

1. Follow the general primate necropsy protocol.
2. Make sure to weigh the fetus and make measurements.
3. In addition, measure the placental disc(s) and weigh the placenta.
4. Note umbilical length and vascular patterns and any evidence of infarction or inflammation.
5. Swab the maternal surface and any lesions for culture and cytology.
6. Note any fetal malformations (i.e. cleft palate).
7. Note dental eruptions.

**Internal Examination**

1. Make sure to note whether ductus arteriosus and foramen ovale are patent.
2. Identify umbilical vein and arteries and check for inflammation. (Make sure to save umbilicus and round ligaments for histology.)
3. Check to see if there is milk or other ingesta in stomach. Take a swab of the stomach if milk is not present, make smears, stain with Wright-Giemsa and Gram stains and check for neutrophils and/or bacteria that would indicate ascending infection in the dam.
4. Check to see if sections of lung sink or float in formalin.
5. Make sure to save a growth plate (e.g. costochondral junction or distal femur) in formalin.
6. Cultures: stomach content or swab of the mucosa; lung; spleen or liver; placental disc and extra-placental membranes. Do both aerobic and anaerobic cultures if possible.

**Tissue Sections**

Take a complete set of tissues from the fetus. Make sure to include sections of the both the placental disc and extra placental fetal membranes and the umbilical cord.
1. Examine the skin over the air sac for signs of fistulae or scars. Note thickness of the skin and presence of fat.

2. Incise the air sac through the skin on the anterior aspect. Note color and texture of air sac lining.

3. Note presence or absence of exudate and characteristics of exudate if present.

4. Note presence or absence of compartmentalization by connective tissue.

5. Note extent of air sacs (e.g. under clavicle, into axilla, etc.)

6. Identify and describe the opening(s) from the larynx into the air sac (e.g. single slit-like opening, paired oval openings etc). Note any exudate.

7. Note the location, size and shape of the opening in the larynx (e.g. midline at base of epiglottis or lateral saccules).

8. Take cultures from at least one site (preferably culture three separate distant sites). Do aerobic, anaerobic and fungal cultures if possible.
PLACENTA SUBMISSION REPORT
Zoological Society of San Diego

PATH #_________________

SITE: ZOO_________ PARK_________ OTHER_________

Date submitted:_____________________________

SPECIES (common name):_________________________________________________
Identification # of infant:___________________________
Enclosure/string:_____________________________
Date of birth ______________________
Time of Birth _________________________________
Date and time of placental delivery:___________________________
Dam___________________________ Sire_________________________

Breeding date for this pregnancy?___________________________

Has dam had previous births? Yes_______ No________
List previous live births

still births

dystocia (difficult births)

Has this dam successfully reared her own young Yes_______ No__________

Was this birth (circle): stillborn or alive term or premature

Was delivery (circle): normal or dystocia normal vaginal, assisted vaginal, or
C-section

What was the approximated interval between fetal and placental deliveries?___________

Additional history or comments:

Submitted by:_________________________
Extension____________________________

183
Species: ____________________________  Pathology # __________________

Placenta received on date: ____________ time: ____________
Placenta examined on date: ____________ time: ____________
Placental type: ______________________________
   cotyledonary, zonary, monodiscoid, bidiscoid, diffuse, other ________________
Umbilical cord: (present, absent)
   Length ____________ Diameter ____________ twists? ____________ knots? ____________
   Number of vessels ____________ Anionic duct? ______________________________
   Point of insertion? ______________________________
Placental condition (circle ones which apply):
   fresh or autolyzed  clean or dirt covered  complete or incomplete
Is there: meconium staining? ____________ blood clot? ____________ mineralization? ____________
   infarction? ____________ % of placenta affected
Placental weight (wash to remove dirt): ______________________________

Diagram the placenta and give measurements (include size & location of rupture and distribution of cotyledons):

Describe the placenta and membranes:
Sections taken: ___________________________ Saved in toto? ___________________________
Cultures? ___________________________ Impression smears? ___________________________
Frozen? ___________________________ Gross photos? ___________________________
Other? ___________________________ 

Diagnoses:

Prosector ___________________________ Pathologist ___________________________
PREVENTIVE MEDICAL PROGRAM FOR CAPTIVE GORILLAS

L. Phillips, Jr.

PREVENTIVE MANAGEMENT PLAN

Certain species, such as the lowland gorilla, are at risk for developing health problems that may go undetected and progress unless a comprehensive medical and management plan is followed. Zoological veterinarians recognize that a preventive medical approach is most effective, and should **minimally** include the following:

1. An appropriate cleaning and disinfection protocol for all gorilla enclosure spaces, with the veterinary department fully aware of the chemical agents in use, their spectrum of action, their designed dilution rate, the frequency of use, and the toxic properties of each agent.

2. Establishment of appropriate diets, adherence to those dietary protocols (addressing both constituents and volumes), and a monitoring program that assures the designed diets are providing the intended nutrition (as assessed, for example, during physical examinations) and whether the diet is being consumed.

3. Establishment of an effective and safe pest control program, with the veterinary staff aware of the level and types of pests present, all pest control methods and pesticides in use (for invertebrate and vertebrate pests), the placement and frequency of use of those products, and the toxic potential of each product used.

4. Establishment of a parasite monitoring and treatment program, ideally designed to lower parasite levels to be of negligible effect on the gorilla population. In reality, parasite levels are controlled but never permanently eliminated. The program should have the practical goal of preventing parasitic loads from becoming a significant negative health factor.

5. Provision of a specific quarantine facility and program for all incoming animals.

6. Development of and adherence to a planned, routine physical examination and health screening program for all members of the gorilla population.

7. Development of and rigid adherence to a program of immunoprophylaxis.

8. An established reporting and communication network among keepers, animal managers, and the veterinary department to establish individual animals requiring potential intervention and observation.

9. A current medical record system, preferably computerized.
Physical Examination

The most basic method for defining the current health status of any animal, including the gorilla, is utilizing the most basic of veterinary medical techniques: the physical examination. Preceded by observations and planning, the examination is conducted through diagnostic observation and sampling, followed by data analysis and interpretation. Subsequently, the results and interpretations are assimilated to produce a planned action to approach a diagnosed problem to initiate correction efforts. The examination may produce a diagnosis of normal health.

Direct assessment of the health of an individual is accomplished via complete physical examination. The indications for physical examinations for gorillas include:

1. **Pre-shipment physical examination**: conducted at the shipping institution to assure the receiving institution is not importing a potential transmissible disease or that the individual animal does not have an underlying medical problem that has been progressive or has been previously undetected. This provides reasonable assurance that the animal will be able to withstand the shipment.

2. **Quarantine physical examination**: conducted at the receiving institution to assure, accompanied by the quarantine period, that no disease condition was contracted during the shipment. Also determines whether the stress of the shipment resulted in exacerbation of an occult health condition.

3. **Routine annual or bi-annual health screen**: conducted at the resident institution as a preventive screening in order to detect changes in health status from the previous examination and to protect the remainder of the group from an introduced disease condition.

4. **Neonatal physical examination**: preferably conducted within seven days of the birth to detect congenital defects, parturition trauma, neonatal disease, malnutrition or maternal neglect. This also incorporates the initiation of the scheduled administration of the vaccination protocol for neonates and juveniles. Individuals that are being mother-reared may be difficult to gain access to for physical examination. Close monitoring of these infants for activity, nursing, skin turgor (hydration status), strength, and the progressive development of the infant should indicate problems that require immobilization of the dam for examination of the infant.

5. **Diagnostic examinations**: indicated by the presentation or reporting of an abnormal health condition in an individual animal or the group. The result of this examination may lead to a single treatment or further immobilizations to conduct further diagnostics or extensive treatment protocols. Expansion of physical examinations to other members of the collection might be indicated if the diagnostic findings in the first individual are suspected to have a transmissible cause or etiology, or have broader management implications—such as nutritional or toxicologic
conditions—that could be affecting other members of the gorilla group (or primate collection).

In order for a physical examination to be complete and conducted safely on a gorilla, it is performed using general anesthesia (induced typically by chemical immobilization; most routine, uncomplicated examinations can be completed using chemical immobilization alone without the need for inhalation anesthesia supplementation). Proper chemical immobilization provides for a patient that is sufficiently relaxed to conduct all necessary diagnostic procedures unobscured by a stressed, semi-mobile patient. With the availability of chemical agents with wide safety margins and sophisticated patient monitoring systems, there is a relatively low risk from anesthetizing gorillas. Simple neonatal examinations may usually be performed satisfactorily without anesthesia; however, if diagnostic procedures such as radiology, ultrasonography, or electrocardiography are indicated by initial physical findings, then inhalation anesthesia can be employed safely.

The SSP husbandry survey sought information regarding physical examination in gorillas in zoological institutions. It included questions regarding the types and frequency of physical examinations conducted at individual institutions and what diagnostic procedures were included in each physical examination, according to body or physical systems. The following is a compilation of the responses received:

1. Interval between routine physical examinations on any one individual: a) performed annually—26 percent of the respondents; b) performed every 2 to 4 years—26 percent of the respondents; c) performed opportunistically, with no indicated time interval between examinations—48 percent of the respondents.

2. Procedures included within a physical examination: respondents reported that they included the following procedures during 100 percent of their physical examinations: a) oral exam—including dental and soft tissue observations; b) auscultation of the heart and lungs; c) temperature, pulse, and respiratory rates; d) abdominal palpation; e) blood samples taken for complete blood counts (CBC), and serum chemistry panels (diagnostic panels); and f) external observation related to the skin, hands, feet.

Sixty-six percent of the time the following procedures were included on each physical examination: a) ophthalmic examination (either direct or indirect); b) otoscopic examination; c) nasal examination (use of cannula to view nasal cavity); and d) rectal culture—85 percent of the respondents performed this test on quarantine examination, but only 66 percent of the time on subsequent examinations.

Fifty percent of the time or less the following procedures were included on each physical examination: a) urogenital examination; b) rectal examination, palpation; c) blood pressure measurement (performed in 33 percent of the examinations); d) radiographs of the thorax; e) radiographs of the abdomen (performed in 25 percent of the examinations); f) electrocardiograms (EKG); g) ultrasonography (performed only 10 percent of the time during examinations); and h) serology for
virus antibody titer panels.

3. Eighty-eight percent of the respondents performed preshipment examinations. These examinations were similar to the routine physical examination 50 percent of the time and 50 percent of the time were in accordance to the receiving institution's requests.

4. Sixty-six percent of the respondents performed incoming quarantine examinations.

Regular physical examinations are critical for the diagnosis of inapparent illness, prevention of disease transmission between collections, and the identification of risk factors that will allow prevention of disease. Routine exams may uncover problems that are easily treatable, such as dental disease. Infectious or parasitic diseases that may not cause clinical signs in an individual may become clinical or be transmitted to others following shipment without pre-shipment and quarantine exams. Regular evaluation of individuals in the population is necessary to identify the causes of and risk factors for significant diseases in gorillas. Cardiovascular disease is a common cause of death in adult and older adult gorillas. Routine examinations could help to detect inapparent disease and allow us to study the course of these illnesses and how they might be prevented. Exams of pregnant animals have allowed the discovery of malpositions, multiple fetuses, and other factors that present a risk to the healthy development of the fetus. Routine examinations may not be necessary in all pregnancies. However, review of medical records and the literature has not demonstrated undo risk to the fetus or dam.

Concerns regarding the impact of immobilization on the individual and the group are commonly shared with zoo veterinarians. These concerns are a primary reason that routine exams are not performed in many situations. No immobilization is completely risk free; however, gorilla immobilizations are not a significant cause of morbidity and mortality. There are also concerns regarding group social disruption caused by the separation and immobilization of a group member. All gorillas must be accessible in the case of an illness. An immobilization that is done opportunistically can be done following training to allow separation from the group and at a time that will minimize impact on the group. A planned immobilization is far less disruptive than an unexpected illness with a protracted course of treatment or the death of a key social member of a gorilla troop.

Recommended Protocol in Routine Physical Examination of Gorillas

1. Accurate body weight--accompanied by a realistic assessment of body condition (e.g. obesity).

2. Direct ophthalmic examination, including fundic exam.

3. Visual oral examination to include gingival and buccal tissues, tongue (and sublingual) teeth, pharynx, glottis, tonsils.

4. Nasal canal examination with speculum.
5. Complete external visual and palpation examination to include axillary, inguinal regions, hand, feet, fingernails and toenails, perineal region, penis and prepuce, vulvar lips.

6. Otic examination with speculum to view ear canal and tympanum.

7. Systematic auscultation of all thoracic quadrants, listening from both anterior (dorsal) and posterior (ventral) aspects. Auscultation of the entire abdomen. Auscultation should be performed in both the supine and sitting (assisted) positions.

8. Abdominal palpation in both the supine and sitting positions.

9. Venipuncture for blood samples to include: CBC, serum chemistry panel, serum for banking, and viral titer panels.

10. Sterile rectal swabs for bacterial culture for most prevalent enteric pathogens (*Salmonella, Shigella, Campylobacter*, etc.).

11. Rectal palpation: males--anus, distal rectum, prostate; females--anus, distal rectum, reproductive tract including cervix, uterus, and ovaries.

12. Vaginal examination in females beginning at six to seven years of age; include speculum examination to visualize the cervical os; be prepared to do vaginal/cervical cytology if indicated. Testicular palpation and caliper measurement, including assessment of turgidity (firmness) of tissue and symmetry.

13. Noninvasive external cuff measurement of blood pressure in the supine, lateral, and sitting positions.

14. Radiological examination of the thorax at least every four years to include imaging of the lungs, heart, and great vessels.

15. Ultrasonographic examination of soft tissues, particularly of female reproductive tracts in animals with poor reproductive histories and the heart of animals with any indication of abnormal cardiovascular function.

16. Intradermal tuberculin testing to be performed at least bi-annually. It is suggested that the eyelid of only one eye be injected with the human tuberculin and other sites (e.g. peri-areolar) be injected with the human tuberculin and avian antigen tuberculin in separate sites. This will assist in potential differentiation of any positive reactions detected in the eyelid.

Positive or suspect reactions should be followed by:

1. Thoracic radiographs.

2. Gastric lavage for acid-fast staining and culture for mycobacteria.
3. Biopsy of the peri-aereolar skin reactions to check for delayed hypersensitivity response.
4. Acid-fast staining of feces to detect passage of organisms.
5. Possible tracheal or bronchial wash for cytology and culture.
6. Consultation with infectious disease personnel for management of the case.

**QUARANTINE**

The survey sought information regarding the institutions' quarantining newly received gorillas, the facilities used, and the typical length of quarantine. Respondents provided responses indicating the following regarding quarantine:

1. Sixty-six percent of responses indicated gorillas were quarantined prior to entrance into the resident gorilla colony; 33 percent of the respondents did not provide quarantine prior to introduction of newly arrived animals into the resident population.

2. Of those animals quarantined, 50 percent were held 30 days, 30 percent were held 60 days, and 20 percent were held 90 days.

3. When quarantined, the animals were held in facilities: a) at the receiving institution in an area separate from the exhibit facility (55 percent); b) at the receiving institution in an area separated (did not indicate the definition of separation), but within the exhibit facility (30 percent); c) at the shipping institution (15 percent), with no isolation after arrival at the receiving institution.

The variability between quarantine protocols currently indicates a consensus needs to be established for consistency among institutions.

**Quarantine Recommendations**

At the initiation of planning for transfer of gorillas between institutions, the complete animal management record should be sent to the receiving institution's primate management personnel. Simultaneously, the complete medical record should be transmitted to the veterinary staff at the receiving institution. The medical records are to include: case records (including outcomes) of instances requiring medical intervention/treatment/diagnostic examination, medical problems listed per individual, results of all diagnostic laboratory testing and their interpretation, and pathology reports of significance in previous members of the group of origin. These documents should be studied and consensus agreement made for acceptance or rejection between the receiving management and veterinary staffs before further plans are formulated for transfer. All questions regarding the history of the gorilla must be answered to assure the receiving zoo's...
staff is prepared and capable of caring for the intended animal. Prior to the actual shipment of any gorilla, any animal(s) should receive a complete physical examination. Without this procedure, the shipping veterinarian cannot provide reasonable assurance that the animal(s) is free of disease or an abnormal health condition. This examination should not be performed during the anesthetic episode for loading into the shipping conveyance, as no samples collected for clinical pathologic analysis can be processed or interpreted before the animal departs from the institution. This provides no measure of the current health status of the particular animal. Neither can an informed decision be made regarding the animal's fitness for transfer.

Quarantine is a minimum 30-day period (90-day period in primate colony situations) that an animal is held in isolation with no contact, either direct or indirect, with the resident gorilla population. This typically is conducted after the animal is transferred from one institution to another. The quarantine facility should be distinctly separate and isolated from the resident housing facility; it is not considered "quarantine" if an incoming animal is held in common facilities with the resident group(s). This facility should provide equal security and health (both physical and psychological) parameters for the animals as the permanent resident facilities. In addition, the keeper staff caring for the quarantined animals should be different from the staff caring for the resident primate collection to prevent transfer of any disease either to or from the newly arrived gorilla(s).

During the quarantine period, parasitologic examinations should be conducted to enable detection and clearance of any parasitic infection prior to release from quarantine. A physical examination should be conducted under anesthesia before release from quarantine to account for the following:

1. Shipment will induce stress on the animal(s) that may stimulate expression of a latent or occult infection or abnormal medical condition. During the shipment, trauma or exposure to an infectious agent may have occurred. Any of these conditions are likely to be detected during a complete physical examination while in quarantine.

2. This examination establishes a baseline database at the receiving institution for the veterinary and clinical pathology laboratory staffs. Interpretations and impressions may differ in some degree between veterinarians and their laboratories (particularly due to individual experience).

Intradermal tuberculin testing should be completed and interpreted at the shipping institution; it is unacceptable to administer the intradermal antigens at the time of shipment and expect the receiving institution veterinarians to read the tests upon arrival of the animals. Most effectively, tuberculin testing should be completed at the shipping institution at least 30 days prior to shipping in order for the tests to be repeated at the receiving institution at the time of the quarantine physical examination.

1. Length of quarantine--minimum of 30 days, extended to 60 days in many institutions due to the potential of parasitic and infectious disease risk to the resident colony. With animals of unknown medical history or imported animals, quarantine should be minimally 90 days.
2. Should have two consecutive negative tuberculin intradermal skin tests before entry into resident colony.

3. Should have three consecutive negative (for parasites) fecal examinations prior to release from quarantine.

4. Recommended vaccination status should be reviewed and updated as needed prior to release (with sufficient time for immune response and protection).

5. Location of quarantine--most effectively, at the receiving institution. Practically, it is realized that some institutions have no acceptable separate facilities that can serve the role of quarantine; either the shipping or receiving institution must have a facility that can provide the isolation. The shipping institution may isolate and perform the quarantine procedure if the receiving institution has no means of physical isolation of new arrivals. In these cases, extra precautions must be made during the transport to avoid contact with other animals or with humans that might result in disease transfer, thus invalidating the quarantine.

**PARASITOLOGY**

The survey requested respondents to indicate what parasites, and at what relative frequency, were diagnosed in gorillas at their institutions. From the responses, most parasites, be they protozoal, helminth, or cestode, were diagnosed only rarely or occasionally. The average frequency of the most prevalent parasites reported from the responses are as follows, listed from most to least prevalent:

**Protozoa:**
1. *Balantidium* spp--diagnosed routinely
2. nonpathogenic ameba--diagnosed routinely
3. trichomonads--diagnosed routinely
4. pathogenic ameba--diagnosed occasionally to routinely
5. *Giardia* spp--diagnosed occasionally
6. coccidia--diagnosed rarely
7. *Cryptosporidia* spp--diagnosed rarely

**Helminths:**
1. Strongyloididae--diagnosed occasionally to routinely
2. *Enterobius* spp.--diagnosed occasionally
3. *Ancylostoma* spp--diagnosed rarely to occasionally
4. ascarids--diagnosed rarely to occasionally

**Cestodes:**
*(Echinococcus, Taenia* spp)--diagnosed rarely
The respondents' answers to questions regarding choice of antiparasitic drug therapy, the doses of each drug, the length of treatment(s), dosage frequency (within 24 hour period), and treatment intervals revealed little consistency among all the responses; institutions used different therapeutic agents for the same organism and the dosages, treatment intervals, and length of treatment exhibited broad ranges (some drug dosages varied by a factor of 6- to 7-fold and length of treatments by 2- to 3-fold). This possibly indicates that institutions may be experiencing poor response to antiparasitic treatment; conversely, there might be inconsistent attention to publication of successful antiparasitic treatment. A separate study is indicated to determine why the broad ranges exist and which of the treatment protocols are actually effective in treating the targeted parasite. Some of the reported doses might be exposing gorillas to excessive drug levels. The goals of these studies should be to develop effective parasitic treatment protocols (efficacious medications and effective dose levels) and for institutions to publish consistently successful antiparasitic protocols.

**IMMUNOPROPHYLAXIS**

A survey was prepared and distributed to all institutions in North America currently holding gorillas asking for the institution's current vaccination program for both juvenile and adult animals. Four broad conclusions can be formulated from the responses obtained:

1. There was consistency among responses regarding the use and timing of administration of the following three vaccines: oral polio, tetanus, and rabies. Ninety percent of the responses indicated that their animals were vaccinated at the proper intervals against these diseases.

2. With lesser consistency, in regard to use among institutions, the following vaccines are employed: measles, DPT (diphtheria, pertussis, tetanus).

3. Rarely did responses indicate zoos vaccinate for the following diseases: influenza, mumps, hepatitis B or A, rubella.

4. There were no responses indicating that zoos vaccinated for the following: hemophilus, BCG, smallpox.

The following is a table of vaccination recommendations for gorillas. It was developed from recommendations in humans and responses from the survey indicating the safe use of these agents in gorillas. Modified live vaccines carry some risk of disease in vaccinated individuals. Protocols for groups that have not previously been vaccinated or animals with concurrent illnesses may require alterations of these recommendations. It may also be difficult to gain access to mother-reared individuals very early in life. Training should be instituted as soon as possible to allow access to the infant without the need for immobilizing the dam.

**VACCINATION RECOMMENDATION**
The following is the recommended vaccination schedule for gorillas in North American zoos.

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 months</td>
<td>DPT'</td>
</tr>
<tr>
<td></td>
<td>IPOL killed polio</td>
</tr>
<tr>
<td></td>
<td>hepatitis B²</td>
</tr>
<tr>
<td></td>
<td>Hemophilus³</td>
</tr>
<tr>
<td>4 months</td>
<td>boost IPOL killed polio</td>
</tr>
<tr>
<td></td>
<td>boost DPT</td>
</tr>
<tr>
<td></td>
<td>boost hepatitis B</td>
</tr>
<tr>
<td></td>
<td>boost Hemophilus</td>
</tr>
<tr>
<td></td>
<td>killed rabies ⁴</td>
</tr>
<tr>
<td>6 months</td>
<td>boost IPOL killed polio</td>
</tr>
<tr>
<td></td>
<td>boost DPT</td>
</tr>
<tr>
<td></td>
<td>boost hepatitis B</td>
</tr>
<tr>
<td></td>
<td>boost Hemophilus</td>
</tr>
<tr>
<td>15 months</td>
<td>measles, mumps, rubella</td>
</tr>
<tr>
<td></td>
<td>killed rabies (on annual basis after this time)</td>
</tr>
<tr>
<td>15-18 months</td>
<td>boost IPOL killed polio</td>
</tr>
<tr>
<td></td>
<td>DPT</td>
</tr>
<tr>
<td>4-6 years</td>
<td>oral polio ⁵</td>
</tr>
<tr>
<td></td>
<td>DPT (tetanus given every 5-9 years after this time or when injury or would indicates)</td>
</tr>
<tr>
<td>10-12 years</td>
<td>measles, mumps, rubella</td>
</tr>
</tbody>
</table>

[¹similar to recommendations for human infants]

¹ diphtheria/pertussis/tetanus
² recommended in areas of risk, as in contact with the public in certain population centers
³ recommended in areas of high prevalence in human population
⁴ recommend use of Imrab®, Rhone-Merieux if contact with feral carnivores is possible.
⁵ oral polio vaccine may put some older, unvaccinated animals at risk due to fecal shedding of vaccine organisms. Current recommendations in humans are to start with killed vaccine (IPOL) and use oral vaccine for later immunization. All members of a troop should be vaccinated.
Zoonotic diseases

T. Meehan, J. Zdziarski

Gorillas (Gorilla gorilla) in the family Pongidae have a close taxonomical relationship to humans and therefore a greater chance for disease transmission or exchange. Zoonosis refers to a disease of animals that may be transmitted to humans under natural conditions (Friel, 1974). However, some diseases may also be transmitted from humans to nonhuman primates. Although many infectious agents are species specific, a large number of organisms do cross species lines and may result in a more virulent form of the disease. Zoonotic pathogens include viral, bacterial, fungal, and parasitic etiologies. All personnel directly and indirectly involved with the care of gorillas should be aware of potential pathogens, their modes of transmission, and preventative measures that can be taken to minimize exposure.

Viral diseases

Nonhuman primates are susceptible to many viruses that are infectious to humans. Serologic surveys have been useful in identifying exposure to viral organisms. Zoonotic viral diseases reported in gorillas are listed in Table 1 (Heldstab et al., 1981; Benirschke, 1983; Lennermann et al., 1984; Ott-Joslin, 1986; Kalter, 1986, 1989; Blakeslee et al., 1987; Myers et al., 1987; Henner, 1990; Janssen and Bush, 1990; Eberle, 1992; Janssen, 1993).

A number of herpesvirus infections have been reported in gorillas. The most common of these is Herpes simplex virus (HSV). One survey showed that more than 60 percent of gorillas were seropositive for HSV-1 (Eberle, 1992). Varicella-Zoster virus (chickenpox) has been reported (Myers et al., 1987), and the author has seen several cases showing typical lesions that were diagnosed by seroconversion. These cases were probably from human sources, because there was no solid barrier between the gorillas and the public.

Measles can cause fatal pneumonia and the disease is highly contagious from humans. Following a number of deaths in wild mountain gorillas thought to be due to measles, a vaccination program was instituted in free-ranging troops visited by the public in Rwanda (Hastings et al., 1991). Vaccination is recommended to prevent disease in zoo populations. Respiratory syncytial virus was seen by the author as an enzootic in a group of great apes, including gorillas. The affected animals showed severe respiratory infection with cough and nasal discharge lasting several weeks, and one infant died of pneumonia. Two animal care staff were also affected, and the disease was implicated by seroconversion of humans involved in the outbreak. Clinical cases of naturally occurring paralytic polio have been reported, and vaccination is recommended (Allmond et al., 1967; Kalter, 1986).

Retroviruses have been reported in gorillas (Lowenstine et al., 1986; Lowenstine and Lerche, 1988, 1993; Lowenstine, 1993). Simian T-lymphotrophic virus 1 (STLV-1) and Human T-lymphotrophic virus 1 (HTLV-1) have been reported to be associated with lymphoma in gorillas (Benirschke, 1983; Strivastava et al., 1986). A chronic fatal disease was seen in three
gorillas seropositive for STLV-1 (Blakeslee et al., 1987). No reported cases of transmission of STLV-1 to humans have been documented; however, it is recommended that precautions be taken to prevent contact with fluids from gorillas and needle-stick injuries from contaminated needles. Hepatitis A and B have been reported in gorillas (Kalter, 1986; Ott-Joslin, 1993). A cluster of hepatitis B seropositives has been reported in a family of gorillas. A keeper associated with these gorillas seroconverted with no clinical signs of disease (Linnemann et al., 1984).

Viruses that cause upper respiratory infection, such as colds and influenza, may be easily transmitted from animal care staff to gorillas and vice versa. These can be an important cause of secondary respiratory disease, particularly in nursery-reared infants.

Rabies, primarily carried by carnivores, is transmissible to other mammalian species and humans and therefore should not be overlooked when discussing diseases with zoonotic potential. Transmission is through bites, scratches, or mucosal contamination. Both the silent and furious forms have been reported in nonhuman primates (Brack, 1987). No cases have been reported in gorillas.

**BACTERIAL DISEASES**

In general, humans and gorillas are susceptible to a broad range of bacterial infections that, under the proper conditions, can be transmitted to and from humans. Therefore, all bacteria should be considered as naturally occurring biohazards. Bacterial infections have been reported from all major organ systems.

Tuberculosis is rare in great apes in North America; however, it has occurred in zoos. Nonhuman primates are susceptible to *Mycobacterium tuberculosis*, *M. bovis*, and *M. avium*, as well as the other mycobacteria (McLaughlin, 1978; Thoen and Hines, 1980; Cousins, 1984). *M. tuberculosis*, *M. bovis*, and *M. kansasii* have been associated with the pulmonary form of the disease (McLaughlin, 1978; Alvarado, 1992). Tuberculosis is transmitted primarily through aerosolized, infected droplets from diseased individuals. Contaminated food, cages, tattoo needles, and bite wounds have all been incriminated as additional modes of transmission. Tuberculosis is a slowly progressive disease with subclinical signs in nonhuman primates until the disease is in advanced stages. Therefore, routine intradermal tuberculin testing of nonhuman primates and employees is important.

Enteric infections, including bacterial, are the most commonly noted cause of morbidity in gorillas, according to a survey of SSP institutions. Enteric pathogens such as *Salmonella*, *Shigella*, *Campylobacter*, and *Eschericia coli* have all been reported in gorillas and may cause human infection following fecal-oral contamination (Benirschke and Adams, 1980; McClure, 1980; Benirschke, 1983; Cousins, 1984; McClure et al., 1986; Kalter, 1989; Janssen and Bush, 1990; Munson and Montali, 1990; Banish et al., 1993; Janssen, 1993; Raphael et al., 1995; Stetter et al., 1995). Other causes of bacterial diarrhea with zoonotic potential, such as *Proteus morgani*, *Citrobacter* spp., and *Yersinia enterocolitica* have been reported in gorillas and other nonhuman primates (Brack, 1987; Janssen and Bush, 1990; Janssen, 1993; Ott-Joslin, 1993; Paul-Murphy, 1993). An asymptomatic carrier state is known to exist with *Salmonella* spp. and *Shigella* spp., and the potential exists with *Campylobacter* spp.
Bacterial pneumonia is also a common cause of morbidity in nonhuman primates, including gorillas. *Bordatella pertussis*, the causative agent of whooping cough, was isolated from gorillas during an outbreak due to human contact (Gustavsson et al., 1990). Other bacteria may be primary invaders or cause infection secondary to other respiratory pathogens.

There are also miscellaneous nonbacterial organisms of zoonotic concern that are worthy of mention. These include spirochetes, mycoplasmas, and rickettsiae, which have been reported in nonhuman primates, including great apes. Mycoplasma species have been implicated as a cause of rheumatoid arthritis in gorillas, including cases where veterinarians experienced signs thought to be due to mycoplasma arthritis that came from contact with affected gorillas (Ott-Joslin, 1993).

**MYCOTIC DISEASES**

Few mycotic infections have been reported in gorillas. Dermatophytes cause infection of the keratinized portion of the skin and adnexa. The typical clinical appearance is localized hair loss in a circular pattern with scaling and crusting of the affected skin. This lesion gives the infection the common name of ringworm. Ringworm due to *Trichophyton* spp. has been reported (Cousins, 1984). Transmission generally occurs through direct contact of lesions and contaminated fomites. Dermatophiliosis, caused by *Dermatophilus congolensis*, has been reported in nonhuman primates (Migaki, 1986). Infection generally involves the superficial layers of the epidermis, causing a dermatitis with a serofibrinous exudate and crust formation. Direct contact with infected animals and insect vectors is responsible for transmission.

**PARASITIC DISEASES**

Parasitism is a commonly reported gastrointestinal disorder of gorillas. Some parasites are known pathogens, others have been occasionally associated with a diseased state, and still others are an incidental finding with unknown resulting pathology. Good husbandry practices can greatly reduce the parasitic load from the animal's environment. Parasitic diseases of zoonotic concern include protozoan, helminthic, and arthropod infestations.

*Balantidium coli*, a ciliated protozoan, is diagnosed routinely in gorillas, according to a survey of SSP institutions. Most commonly, gorillas with *Balantidium* are persistently infected yet asymptomatic, although the parasite can cause invasive colitis and typhlitis in some individuals, with occasional mortalities (Benirschke and Adams, 1980; Cousins, 1984; Kalter, 1989; Janssen and Bush, 1990; Lee and Prowten, 1990; Mainka, 1990; Munson and Montali, 1990; Lee et al., 1991; Janssen, 1993). Transmission is through the fecal-oral route, with infective cysts that can be easily identified on a direct or stained fecal smear. Pathogenic amebae are diagnosed occasionally to routinely by SSP institutions. Amebiasis caused by *Entamoeba histolytica* may range from the asymptomatic carrier state to acute dysentery (Paul-Murphy, 1993). The environmental cystic stage, which is highly resistant to desiccation and disinfectants, is transmitted through ingestion of contaminated food and water. In rare cases, trophozoites may enter the lymphatics and be carried to the major organs, causing abscess formation (Toft, 1986).
*Giardia lamblia* is a flagellate protozoan parasite that causes mucoid diarrhea. It is diagnosed occasionally by SSP institutions. An asymptomatic carrier state can exist. Because it is an upper intestinal infection, identification of the trophozoite stage is difficult. The infective cystic stage can be identified on fecal smears stained with iodine or a trichrome stain (Swenson, 1993). The cyst may remain viable for up to two weeks in a moist environment and is transferred through contaminated food or fomites.

*Strongyloides stercoralis* is a helminth parasite diagnosed occasionally to routinely in gorillas at SSP institutions. It has a direct life-cycle in which the adult female lays her eggs in the intestinal mucosa. The larvae hatch, migrate to the intestinal lumen, and are passed in the feces. The rhabditiform larvae can develop into nonparasitic, free-living adult worms or infective filariform larvae, which may penetrate intact skin. Autoinfection occurs when the rhabditiform larvae molt into the infective stage while still within the intestinal lumen. The larvae migrate to the bloodstream and are carried to the lungs, where they are coughed up and swallowed (Leeflag and Markham, 1986). Zoonotic transmission can occur through the fecal-oral route or skin penetration.

Human parasites can be transmitted to nonhuman primates through food items contaminated with human feces. *Enterobius vermicularis* (pinworms) is a human parasite diagnosed occasionally in gorillas. Clinical signs of disease are generally limited to anal pruritus. Once established in a population, infested animals can act as a reservoir for humans. Other helminth parasites identified in gorillas with zoonotic potential are *Trichuris trichuria*, *Oesophagostomum* spp., *Ascaris lumbricoides*, cestodes, and *Anatrichosoma cutaneum* (Toft, 1986).

**GUIDELINES**

Good animal husbandry and management practices can reduce the risk of transmission of diseases within the gorilla troop or to humans. Some important points to consider when working with nonhuman primates are (Richardson, 1987; Ott-Joslin, 1993):

1. Protective clothing should be worn when in direct contact with the animal or animal secretions (blood, urine, feces, tissue infected or contaminated with microorganisms). Protective clothing includes coveralls, lab coats, gowns, gloves, goggles, and face masks. The protective clothing should be changed when it is soiled. Soaking the clothing in a chemical disinfectant is advisable when handling infectious material, and ideally a laundering service capable of handling contaminated material should be provided by the institution.

2. Strong personal hygiene practices are a must when working with nonhuman primates. Care should be taken not to touch the face, especially the mouth, nose, and eyes. Inanimate objects such as pens, locks, and countertops can harbor pathogens. Hand washing is considered to be one of the most important preventative measures in reducing an individual's risk of infection. Hands should be washed after handling an animal, an animal's waste, soiled bedding and food, or tissues and diagnostic samples. There should be no eating, drinking, or
smoking in the animal areas. Separate refrigerators should be utilized for storing animal food and human food. Animal bowls and utensils should be stored separately and not be used for preparing staff food.

3. Bedding, food, fecal matter, and other items in an animal's enclosure should be removed before cleaning to decrease the potential of aerosolizing infectious material and improve the effectiveness of the disinfectant agent. Protective clothing should be worn when cages are cleaned. Additional protective devices such as face shields, goggles, or respirators should be worn when using high power hoses or steam cleaners.

4. Six air exchanges per hour is the recommended minimum ventilation rate to control odors. Ideally, the air from animal areas should be 100 percent discharged to the outside without recirculation.

5. Facilities should maintain an active pest control program.

6. A pre-employment physical examination should be done on all employees, and a baseline serum sample should be collected at that time. The serum sample should be stored in an ultracold (-70°C) freezer. Employees should be TB tested and receive appropriate vaccinations.

7. Employees should report all bites and scratches to their supervisors, and they should seek medical attention.

8. Employees with upper respiratory infections or open ulcers on the skin or mouth should not work directly with nonhuman primates. If they must work in the area, they should wear gloves and face masks. Employees with more serious illnesses (diarrhea, fever, etc.) should seek medical attention. They should inform their primary-care physician that they work with nonhuman primates.

Finally, a good preventative medicine program should be designed to include quarantine, routine examinations, parasite detection and control, immunization, and tuberculin testing. Strict quarantine of all new arrivals will minimize the transmission of disease to the animal collection and human caretakers.
IMMOBILIZATION AND SHIPPING

T. Meehan

RECOMMENDED METHODS FOR IMMOBILIZATION

Based on the medical survey response, the most common injectable anesthetics used on gorillas are either ketamine HCl alone or telatamine HCl and zolazepam (Telazol). Other less frequently used drugs include Ketamine HCl in combination with Xylazine HCl, diazepam in combination with telatamine and zolazepam and telatamine zolazepam with ketamine supplementation. The most commonly used dosages in healthy gorillas in the survey were:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Ketamine</th>
<th>Telazol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult males</td>
<td>8-11 mg/kg</td>
<td>2-5 mg/kg</td>
</tr>
<tr>
<td>Adult females</td>
<td>4-16 mg/kg</td>
<td>2-3 mg/kg</td>
</tr>
<tr>
<td>Juvenile males</td>
<td>5-10 mg/kg</td>
<td>2.5 mg/kg</td>
</tr>
<tr>
<td>Juvenile females</td>
<td>5-10 mg/kg</td>
<td>2-5 mg/kg</td>
</tr>
<tr>
<td>Neonates</td>
<td>4-10 mg/kg</td>
<td></td>
</tr>
</tbody>
</table>

The inhalant anesthetic of choice is isoflurane gas. In adults this is administered during longer procedures following immobilization with injectibles. In neonates, depending on the animal's size and cooperation, it may be used for induction and general anesthesia. For induction, the isoflurane is delivered at a concentration of 3 to 5 percent and then maintained at .5 to 1.5 percent as necessary. The gas is administered either via face mask or via endotracheal tube following intubation.

Animals are routinely fasted prior to planned immobilization. The length of fast (including both food and water) may vary depending on institution and environmental restrictions.
PREPARATIONS FOR SHIPMENT/PRE-SHIPMENT EXAMS

Based on the medical survey, a majority of institutions performed routine examinations prior to shipment (see Tables 1 and 2). In general, these were thorough and were based both on the criteria of the shipping institution and the requests of the receiving institution.

Table 1. Procedures Included in Physical Examinations (Results of SSP Survey)

<table>
<thead>
<tr>
<th>Exam/Procedure</th>
<th>Always</th>
<th>Mostly</th>
<th>Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otoscopic Exam</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Ophthalmic Exam/Direct</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Ophthalmic Exam/Indirect</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Nasal Exam</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Oral Exam/Dental</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Oral Exam/Soft Tissue</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Auscultation/Heart</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Auscultation/Lungs</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Temp./Pulse/Respir.</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Abdominal Palpation</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Urogenital Exam</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Rectal Palpation</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Integument Exam</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Musculoskeletal Exam</td>
<td></td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>
Table 2. Procedures Included in Diagnostic Examinations (Results of SSP Survey)

<table>
<thead>
<tr>
<th>Diagnostic Test</th>
<th>Always</th>
<th>Mostly</th>
<th>Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographs-Chest (L/VD/AP)</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Radiographs-Abdomen</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>EKG</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Echocardiography</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Abdominal Ultrasound</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Complete Blood Count</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemistry</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Virology</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Skin Scraping</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Fecal Direct/Float</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viral Culture</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Rectal/Fecal Culture</td>
<td></td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

**PREPARATION FOR SHIPMENT**

If immobilization for shipment is necessary, the animal is usually fasted. Enough time is allowed for complete recovery in the shipping crate prior to movement.

**CRATES**

The crate must be made of high quality materials which can adequately contain the animal which is to be held. There should be no sharp points either inside or outside of the crate. There should be spaces or vents in the crate large enough to provide adequate ventilation. The crate must meet the size criteria for the animal and the limitation of the carrier. A port should be available externally to add water for internal access and food should be easily added. Bedding that will provide padding for the animal as well as serve to hold feces and urine should be placed within the crate. The crate bottom should minimize fluid loss from the crate onto the carrier surface. The Animal Welfare Act addresses these issues which cover transportation standards.
MODES OF TRANSPORTATION

For long distance travel, airplane transport is usually preferable. The International Air Travel Association has created guidelines for nonhuman primates, not including members of the family Pongidae (see pages 193 and 194). Because these guidelines do not include gorillas, they are included simply as a reference source. For shorter distances and to transport animals to the airport, an appropriately sized vehicle is selected. The crate should be housed within a closed vehicle and the animal should be protected from environmental stress (i.e., air conditioning in hot weather, heat in cold weather). Precautions should be taken to assure backup transport should the primary vehicle breakdown. Additional food and water should accompany the shipment. In recent years, airline restrictions have in some instances necessitated ground transport for longer distances. In these cases, a backup vehicle usually accompanies the primary vehicle, so in the event of a breakdown, the crate can be transferred.

ACCOMPANYING SHIPMENT

An animal caretaker should always accompany the gorilla from point of origin through arrival at the receiving institution. This person serves to insure the smooth transport of the animal, supplement food and water, provide some assurance to the animal, and to facilitate the passage of care information at the receiving institution. In cases where the animal's health is of increased concern, a veterinarian will accompany the shipment. In such instances, immobilization supplies and equipment as well as emergency drugs are brought along.

GORILLAS ENTERING THE USA FROM OTHER COUNTRIES

The Center for Disease Control has formulated strict guidelines for the international transport of nonhuman primates into the USA. To facilitate adherence to the guidelines it is requested that the CDC representative be contacted well in advance of such transports.
TRANSPORTATION STANDARDS

Authority: Secs. 3, 5, 6, 10, 11, 14, 16, 17, 21; 80 Stat. 353; 84 Stat. 1561, 1562, 1563, 1564; 90 Stat. 418, 419, 420, 423; (7 U.S.C. 2133, 2135, 2136, 2140, 2141, 2144, 2146, 2147, 2151); 37 FR 28464, 28477, 38 FR 19141.


3.136 CONSIGNMENTS TO CARRIERS AND INTERMEDIATE HANDLERS

(a) Carriers and intermediate handlers shall not accept any live animals presented by any dealer, research facility, exhibitor, operator of an auction sale, or other person, or any department, agency, or instrumentality of the United States or any State or local government for shipment, in commerce, more than four hours prior to the scheduled departure of the primary conveyance on which it is to be transported: provided, however, that the carrier or intermediate handler and any dealer, research facility, exhibitor, operator of an auction sale, or other person, or any department, agency, or instrumentality of the United States or any state or local government may mutually agree to extend the time of acceptance to not more than six hours if specific prior scheduling of the animal shipment to destination has been made.

(b) Any carrier or intermediate handler shall only accept for transportation or transport, in commerce, any live animal in a primary enclosure which conforms to the requirements set forth in § 3.137 of the standards: provided, however, that any carrier or intermediate handler may accept for transportation or transport, in commerce, any live animal consigned by any department, agency, or instrumentality of the United States having laboratory animal facilities or exhibiting animals or any licensed or registered dealer, research facility, exhibitor, or operator of an auction sale if the consignor furnishes to the carrier or intermediate handler a certificate, signed by the consignor, stating that the primary enclosure complies with § 3.137 of the standards, unless such primary enclosure is obviously defective or damaged and it is apparent that it cannot reasonably be expected to contain the live animal without causing suffering or injury to such live animal. A copy of such certificate shall accompany the shipment to destination. The certificate shall include at least the following information:

1. Name and address of the consignor;

2. The number of animals in the primary enclosure(s);

3. A certifying statement (e.g., "I hereby certify that the --- (number) primary enclosure(s) which are used to transport the animal(s) in this shipment complies (comply) with USDA standards for primary enclosures (9 CFR Part 3).")); and

4. The signature of the consignor, and date.

(c) Carriers or intermediate handlers whose facilities fail to meet the minimum
temperature allowed by the standards may accept for transportation or transport, in commerce, any live animal consigned by any department, agency, or instrumentality of the United States or of any State or local government, or by any person (including any licensee or registrant under the Act, as well as any private individual) if the consignor furnishes to the carrier or intermediate handler a certificate executed by a veterinarian accredited by this Department pursuant to part 160 of this title on a specified date which shall not be more than 10 days prior to delivery of such animal for transportation in commerce, stating that such live animal is acclimated to air temperatures lower than those prescribed in paragraphs 3.141 and 3.142. A copy of such certificate shall accompany the shipment to destination. The certificate shall include at least the following information:

1. Name and address of the consignor;

2. The number of animals in the shipment;

3. A certifying statement (e.g., "I hereby certify that the animal(s) in this shipment is (are), to the best of my knowledge, acclimated to air temperatures lower than 7.2 C (45 F)"; and

4. The signature of the USDA accredited veterinarian, assigned accreditation number, and date.

(d) Carriers and intermediate handlers shall attempt to notify the consignee at least once in every 6 hour period following the arrival of any live animals at the animal holding area of the terminal cargo facility. The time, date, and method of each attempted notification and the final notification to the consignee and the name of the person notifying the consignee shall be recorded on the copy of the shipping document retained by the carrier or intermediate handler and on a copy of the shipping document accompanying the animal shipment.


3.137 PRIMARY ENClosures USED TO TRANSPORT LIVE ANIMALS

No dealer, research facility, exhibitor, or operator of an auction sale shall offer for transportation or transport, in commerce, any live animal in a primary enclosure which does not conform to the following requirements:

(a) Primary enclosures, such as compartments, transport cages, cartons, or crates, used to transport live animals shall be constructed in such a manner that (1) the structural strength of the enclosure shall be sufficient to contain the live animals and to withstand the normal rigors of transportation; (2) the interior of the enclosure shall be free from any protrusions that could be injurious to the live animals contained therein; (3) the openings of such enclosures are easily accessible at all times for emergency removal of the live animals; (4) except as provided in paragraph (g) of this section, there are ventilation openings located on two opposite walls of the primary enclosure and the ventilation openings on each such wall shall be at least 16 percent of
the total surface area of each such wall, or there are ventilation openings located on all four walls
of the primary enclosure and the ventilation openings on each such wall shall be at least 8
percent of the total surface area of each such wall: provided, however, that at least one-third of
the total minimum area required for ventilation of the primary enclosure shall be located on the
lower one-half of the primary enclosure and at least one-third of the total minimum area required
for ventilation of the primary enclosure shall be located on the upper one-half of the primary
enclosure; (5) except as provided in paragraph (g) of this section, projecting rims or other
devices shall be on the exterior of the outside walls with any ventilation openings to prevent
obstruction of the ventilation openings and to provide a minimum air circulation space of 1.9
centimeters (.75 inch) between the primary enclosure and any adjacent cargo or conveyance-wall;
and (6) except as provided in paragraph (g) of this section, adequate handholds or other
devices for lifting shall be provided on the exterior of the primary enclosure to enable the
primary enclosure to be lifted without tilting and to ensure that the person handling the primary
enclosure will not be in contact with the animal.

(b) Live animals transported in the same primary enclosure shall be of the same species
and maintained in compatible groups. Live animals that have not reached puberty shall not be
transported in the same primary enclosure with adult animals other than their dams. Socially
dependent animals (e.g., sibling, dam, and other members of a family group) must be allowed
visual and olfactory contact. Any female animal in season (estrous) shall not be transported in the
same primary enclosure with any male animal.

(c) Primary enclosures used to transport live animals shall be large enough to ensure that
each animal contained therein has sufficient space to turn about freely and to make normal
postural adjustments: provided, however, that certain species may be restricted in their
movements according to professionally acceptable standards when such freedom of movement
would constitute a danger to the animals, their handlers, or other persons.

(d) Primary enclosures used to transport live animals as provided in this section shall
have solid bottoms to prevent leakage in shipment and still be cleaned and sanitized in a manner
prescribed in § 3.131 of the standards, if previously used. Such primary enclosures shall contain
clean litter of a suitable absorbent material, which is safe and nontoxic to the live animals
contained therein, in sufficient quantity to absorb and cover excreta, unless the animals are on
wire or other nonsolid floors.

(e) Primary enclosures used to transport live animals, except where such primary
enclosures are permanently affixed in the animal cargo space of the primary conveyance, shall be
clearly marked on top and on one or more sides with the words "Live Animal" or "Wild
Animal", whichever is appropriate, in letters not less than 2.5 centimeters (1 inch) in height, and
with arrows or other markings to indicate the correct upright position of the container.

(f) Documents accompanying the shipment shall be attached in an easily accessible
manner to the outside of a primary enclosure which is part of such shipment.

(g) When a primary enclosure is permanently affixed within the animal cargo space of
the primary conveyance so that the front opening is the only source of ventilation for such
primary enclosure, the front opening shall open directly to the outside or to an unobstructed aisle
or passageway within the primary possible. Carriers and intermediate handlers holding any live conveyance. Such front ventilation opening shall be at least 90 percent of the total surface area of the front wall of the primary enclosure and covered with bars, wire mesh or smooth expanded metal.


3.138 PRIMARY CONVEYANCES (MOTOR VEHICLE, RAIL, AIR, MARINE)

(a) The animal cargo space of primary conveyances used in transporting live animals shall be designed and constructed to protect the health, and ensure the safety and comfort of the live animals contained therein at all times.

(b) The animal cargo space shall be constructed and maintained in a manner to prevent the ingress of engine exhaust fumes and gases from the primary conveyance during transportation in commerce.

(c) No live animal shall be placed in an animal cargo space that does not have a supply of air sufficient for normal breathing for each live animal contained therein, and the primary enclosures shall be positioned in the animal cargo space in such a manner that each live animal has access to sufficient air for normal breathing.

(d) Primary enclosures shall be positioned in the primary conveyance in such a manner that in an emergency the live animals can be removed from the primary conveyance as soon as possible.

(e) The interior of the animal cargo space shall be kept clean.

(f) Live animals shall not be transported with any material, substance (e.g., dry ice) or device which may reasonably be expected to be injurious to the health and well-being of the animals unless proper precaution is taken to prevent such injury.

3.139 FOOD AND WATER REQUIREMENTS

(a) All live animals shall be offered potable water within 4 hours prior to being transported in commerce. Dealers, exhibitors, research facilities and operators of auction sales shall provide potable water to all live animals transported in their own primary conveyance at least every 12 hours after such transportation is initiated, and carriers and intermediate handlers shall provide potable water to all live animals at least every 12 hours after acceptance for transportation in commerce: provided, however, that except as directed by hibernation, veterinary treatment or other professionally accepted practices, those live animals which, by common accepted practices, require watering more frequently shall be so watered.

(b) Each live animal shall be fed at least once in each 24 hour period, except as directed
by hibernation, veterinary treatment, normal fasts, or other professionally accepted practices. Those live animals which, by common accepted practice, require feeding more frequently shall be so fed.

(c) A sufficient quantity of food and water shall accompany the live animal to provide food and water for such animals for a period of at least 24 hours, except as directed by hibernation, veterinary treatment, normal fasts, and other professionally accepted practices.

(d) Any dealer, research facility, exhibitor or operator of an auction sale offering any live animal to any carrier or intermediate handler for transportation in commerce shall affix to the outside of the primary enclosure used for transporting such live animal, written instructions concerning the food and water requirements of such animal while being so transported.

(e) No carrier or intermediate handler shall accept any live animals for transportation in commerce unless written instructions concerning the food and water requirements of such animal while being so transported is affixed to the outside of its primary enclosure.

3.140 CARE IN TRANSIT

(a) During surface transportation, it shall be the responsibility of the driver or other employee to visually observe the live animals as frequently as circumstances may dictate, but not less than once every 4 hours, to assure that they are receiving sufficient air for normal breathing, their ambient temperatures are within the prescribed limits, all other applicable standards are being complied with and to determine whether any of the live animals are in obvious physical distress and to provide any needed veterinary care as soon as possible. When transported by air, live animals shall be visually observed by the carrier as frequently as circumstances may dictate, but not less than once every 4 hours, if the animal cargo space is accessible during flight. If the animal cargo space is not accessible during flight, the carrier shall visually observe the live animals whenever loaded and unloaded and whenever the animal cargo space is otherwise accessible to assure that they are receiving sufficient air for normal breathing, their ambient temperatures are within the prescribed limits, all other applicable standards are being complied with and to determine whether any such live animals are in obvious physical distress. The carrier shall provide any needed veterinary care as soon as possible. No animal in obvious physical distress shall be transported in commerce.

(b) Wild or otherwise dangerous animals shall not be taken from their primary enclosure except under extreme emergency conditions: provided, however, that a temporary primary enclosure may be used, if available, and such temporary primary enclosure is structurally strong enough to prevent the escape of the animal. During the course of transportation, in commerce, live animals shall not be removed from their primary enclosures unless placed in other primary enclosures or facilities conforming to the requirements provided in this subpart.

3.141 TERMINAL FACILITIES
Carriers and intermediate handlers shall not commingle live animal shipments with inanimate cargo. All animal holding areas of a terminal facility of any carrier or intermediate handler wherein live animal shipments are maintained shall be cleaned and sanitized in a manner prescribed in § 3.141 of the standards often enough to prevent an accumulation of debris or excreta, to minimize vermin infestation and to prevent a disease hazard. An effective program for the control of insects, ectoparasites, and avian and mammalian pests shall be established and maintained for all animal holding areas. Any animal holding area containing live animals shall be provided with fresh air by means of windows, doors vents, or air conditioning and may be ventilated or air circulated by means of fans, blowers, or an air conditioning system so as to minimize drafts, odors, and moisture condensation. Auxiliary ventilation, such as exhaust fans and vents or fans or blowers or air conditioning shall be used for any animal holding area containing live animals when the air temperature within such animal holding area is 23.9 C (75 F) or higher. The air temperature around any live animal in any animal holding area shall not be allowed to fall below 7.2 C (45 F) nor be allowed to exceed 29.5 C (85 F) at any time; provided, however, that no live animal shall be subjected to surrounding air temperatures which exceed 23.9 C (75 F) for more than 4 hours at any time. To ascertain compliance with the provisions of this paragraph, the air temperature around any live animal shall be measured and read outside the primary enclosure which contains such animal at a distance not to exceed .91 meters (3 feet) from any one of the external walls of the primary enclosure and on a level parallel to the bottom of such primary enclosure at a point which approximates half the distance between the top and bottom of such primary enclosure.


3.142 HANDLING

(a) Carriers and intermediate handlers shall move live animals from the animal holding area of the terminal facility to the primary conveyance and from the primary conveyance to the animal holding area of the terminal facility as expeditiously as animal in an animal holding area of a terminal facility or in transporting any live animal from the animal holding area of the terminal facility to the primary conveyance and from the primary conveyance to the animal holding area of the terminal facility, including loading and unloading procedures, shall provide the following:

1. Shelter from sunlight. When sunlight is likely to cause overheating or discomfort, sufficient shade shall be provided to protect the live animals from the direct rays of the sun and such live animals shall not be subjected to surrounding air temperatures which exceed 29.5 C (85 F), and which shall be measured and read in the manner prescribed in § 3.141 of this part, for a period of more than 45 minutes.

2. Shelter from rain or snow. Live animals shall be provided protection to allow them to remain dry during rain or snow.

3. Shelter from cold weather. Transporting devices shall be covered to provide protection for live animals when the outdoor air temperature falls below 10 C (50
F) and such live animals shall not be subjected to surrounding air temperatures which fall below 7.2 C (45 F), and which shall be measured and read in the manner prescribed in § 3.141 of this part, for a period of more than 45 minutes unless such animals are accompanied by a certificate of acclimation to lower temperatures as prescribed in § 3.136(c).

(b) Care shall be exercised to avoid handling of the primary enclosure in such a manner that may cause physical or emotional trauma to the live animal contained therein.

(c) Primary enclosures used to transport any live animal shall not be tossed, dropped, or needlessly tilted and shall not be stacked in a manner which may reasonably be expected to result in their falling.

The process of shipping a gorilla or other great ape entails more than just a well thought out plan and coordination by the involved institutions. It entails familiarization with federal, state, local and international laws, and the requirements imposed by these external agencies. Gorillas are regulated by the United States Department of Agriculture (USDA); Convention on International Trade of Endangered Species (CITES); Endangered Species Act (ESA); Centers for Disease Control (CDC); and--for air transport--the International Air Transport Association (IATA). These agencies are responsible for monitoring the process by which we move and care for these animals.

REGULATIONS

USDA provides minimum standards on the transportation of nonhuman primates (NHP's). There are specifications for crate design, transport vehicle, temperature during transit, food and water, and general care of the animal (Code of Federal Regulations 9, section 3.86 through 3.91; also see Transportation section, this volume). According to USDA, the crate must be of structural strength to contain the animal and withstand the rigors of transportation. The interior of the crate should be checked to ensure that no objects are protruding. The crate must have a solid leak-proof bottom or a removable leak-proof tray and be provided with sufficient absorbent material to collect any waste. Ventilation holes must be made on at least two sides of the crate and be covered with wire mesh, bars, or smooth expanded metal. Depending on the size of the crate, either handles or a forklift spacer base must be provided. This will improve ground handling and loading procedures and eliminate the potential for any physical contact with the animal.

IATA regulations are enforced by the airline industry and are accepted by CITES as the minimum guidelines for air transport. Commercial airlines are adhering closely to these regulations and are likely to reject the shipment if crates do not conform to the IATA specifications. IATA has crate specifications for both juvenile and adult animals. Unlike USDA, IATA regulations provide crate diagrams and list specific materials to be used in building the crate. The IATA Live Animals Regulations manual is published annually and can be obtained from: Publications Assistant, IATA, 2000 Peel Street, Montreal, Quebec, Canada H3A 2R4.

CITES and ESA regulations must be observed when planning international imports and exports. Gorillas are listed on the Endangered Species Act (50 CFR 17.1 through 17.22) and are classified as Appendix 1 under CITES (50 CFR 23.1 through 23.23). This classification requires all appropriate import and export permits.

All imports of nonhuman primates are scrutinized and monitored by CDC. NHP's entering the U.S. must be quarantined for a minimum of 31 days at an approved CDC facility. As of 1996, CDC lists Brookfield Zoo, St. Louis Zoo, San Diego Zoo, Denver Zoo, Columbus Zoo,
Woodland Park Zoo, and the Bronx Zoo as the only zoological institutions licensed to quarantine imports of NHP's. Institutions not licensed with CDC should make quarantine arrangements with one of the above facilities. The interim guidelines/protocols of the CDC are numerous and detailed. The CDC licensed institution is held responsible for ensuring that all protocols are followed from the point of origin through quarantine (Cook, 1994). Therefore the first step in planning your importation is to secure space with a licensed institution and to involve them in the process.

**TRANSPORTATION**

In executing the transfer of a gorilla, it is necessary to map out and precisely orchestrate all steps involved in moving the animal. The planning process from inception until final delivery can take weeks or even months, if dealing with an international transport. Foreseeing any possible pitfalls, as well as developing contingency plans, should be part of the planning process. Before the shipment takes place, there are some obvious and necessary steps involved, including: 1) locating an appropriate crate, 2) determining the best and quickest mode of transportation, and 3) verifying any necessary medical testing. Other non-animal but significant factors include: 1) obtaining adequate permits, 2) contacting experienced transporters and pricing out the costs, 3) taking into consideration weather conditions at both locations, and 4) ascertaining available quarantine space at the receiving institution.

The process of how the animal will be transferred into the crate is another variable in the shipping plan. The decision about whether the animal will be crate trained (based on the recommendations under Conditioning in this volume) or tranquilized is one that requires forethought. Variables that play a role in determining which process will be used include the animal's disposition (aggressive or docile), the structure of the facility (e.g., available space to position crates in holding areas), and timing of required medical tests.

Although it is not a regulation requirement, it is strongly recommended that an individual who is familiar with the gorilla (preferably the caretaker) accompany the animal during transport. The presence of a familiar caretaker will contribute to the animal's welfare by alleviating some of the stress associated with transport. In addition, the caretaker can provide the receiving institution with direct information about the animal's behavior.

Special consideration must be taken during shipment to ensure that the animal is kept in an environment where the temperature is conducive to its health and well-being. Regardless of whether you are using surface or air transportation, the vehicle's holding area must have adequate ventilation as well as separate temperature adjustment devices.

There are several factors that determine the best mode of transportation to use, including the age of animal, the place of destination, and the weight and size of the crate. Today, the most used and reliable ways of transporting a gorilla are: 1) ground transportation (via the institution's vehicle, rented truck, or by an experienced exotic animal transporter); and 2) air transfer (commercial carrier or freight carriers). Whether you are shipping by surface or by air, you should always calculate enough time for unforeseen delays. These could include weather
conditions, vehicle or mechanical failure, or traffic delays.

The use of complete ground transportation vs. air transportation allows the shipper more control over the transfer process. The greatest advantage is that it permits visual examinations at whim in order to detect any changes in the animal or its immediate environment. As part of your planning process, research the distance that you are traveling and calculate the approximate distance that will be covered per day. For lengthy trips, it is preferable to have unmarked vehicles in order to discourage curious bystanders during any stops. Also as part of your contingency plan, have the phone numbers of institutions which are within your traveling route available for possible assistance during an emergency. Appropriate paperwork is also required, including any necessary state permits for transporting animals.

The biggest advantage of using air transportation is the reduction of travel time, thus diminishing the amount of stress the animal has to endure during the shipping process. [In most cases, air transport is only one part of the shipping process. Some zoological institutions are located in remote areas away from major airports, making it often necessary to make the remainder of the trip using ground transportation.] The two most commonly used forms of air transport are: commercial air carriers and freight carriers.

Commercial air carriers are the least expensive of the two, but they are limited by their cargo areas. They also have more restrictions and are less willing to shift or modify their procedures or protocols. Obtaining a cargo reservation and an airway bill on a commercial airline will not guarantee the shipment will be accepted. Commercial airlines are more likely to cancel your reservations without warning if they have too many or not enough passengers or even excessive mail. The possibility of having your reservation canceled increases during busy schedules. Therefore, every effort should be made to avoid air transportation around holidays. If at all possible, avoid multi-connecting flights, and choose flights that have minimal ground layover time. Always inform airline personnel of any special services or requirements for the animal through prior arrangements, and obtain written confirmation that these requirements will be met.

Adult gorillas are very difficult to ship by commercial air carriers because of the weight and dimensions of the crate. Most U.S. domestic commercial carriers have a maximum of eight or four hundred pounds per unit of cargo, and/or the cargo doors are usually too small to position the crate properly. Another disadvantage is that most aircraft have no access to the cargo area from the main passenger level, and their cargo areas are not suitable for human accommodations. If access to the animal is not possible, then the animal should be checked just prior to loading and immediately upon arrival.

Locating a freight carrier that accepts live animals can be difficult, but not impossible. The most commonly known and used is Federal Express. Another carrier that accepts live animals is American International Freight. Animal shipments for these carriers are not routine and therefore are considered "special services." These carriers will not accept the animal unless it is accompanied by an attendant. Accessibility to the animal, a degree of control over the number of airline personnel with access to the animal, and full supervision of the loading and unloading processes are the benefits of using these more expensive carriers. Other than expense, the primary disadvantage of freight carriers is that they have limited destinations and flight
schedules.

INTERNATIONAL TRANSPORTATION

Since the formation of the SSP and similar groups, gorilla transfers have increased. While most of these transfers are within North America, there may be a need to exchange animals with other countries in order to maintain genetically and demographically healthy populations. Therefore, in addition to the U.S. regulations and shipping processes outlined, care must be taken to investigate additional restrictions and regulations in planning imports or exportation of gorillas.

In conclusion, our primary concern during the entire shipping process is the safety, comfort and welfare of the animal. Achieving this in a timely manner with few obstacles can at times be a challenge. Animal transportation is still an evolving process due to changes in regulations and advancement or refinement in available modes of transportation. The challenge is learning to adapt to these changes. Every transfer is unique, depending upon the age and size of the animal, its behavior, and the geographic destination.

SUMMARY

1. Develop an itinerary, including a contingency plan, far in advance.

2. Verify all local, state, federal and international laws if necessary. (If in doubt about a particular section of a regulation, call and clarify; sometimes your interpretation is different than that intended. It is up to you to verify with the governing agency.)

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

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

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

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

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

THE DAY PRIOR TO SHIPPING
1. Reconfirm with transporter.

2. Check weather conditions in all route locations.

3. Synchronize all the players both internally and externally on time schedule and procedure.

4. Compile paperwork:

Domestic:
- health certificate
- USDA transfer form (7020)
- crate labels
- data transfer form
- feeding and watering labels
- specimen report
- air waybill (if by air)
- medical records
- USDA transport permits (if required)

International:
- CITES/ESA permits
- crate labels
- specimen report
- feeding and watering labels
- air waybill
- medical records
- Pro-forma Invoice (required by Customs)
- U.S. F&WS declaration of Importation/Exportation #3-177
- USDA International Health Certificate #17-140 (signed and stamped by USDA).
DESIGN

DESIGN
DESIGN

By N. Lash, J. Ogden, L. Meller, V. Wall

OVERVIEW

This chapter addresses the multi-disciplinary approach needed for the appropriate design of gorilla facilities in zoos. We have synthesized a wide range of ideas presented in the literature, including experiences of past and present animal managers and research from both the field and captivity. However, the subject is still evolving. While the goal here is to establish design guidelines, we do not claim that these recommendations will apply to all facilities or situations. As always, responsibility for safe captive management of gorillas rests with the institutions and individuals charged with their care.

This chapter is organized into three basic sections: 1) information about gorillas in the wild; 2) gorillas in captivity; and 3) design recommendations and survey results. The chapter concludes with a checklist of design recommendations for future gorilla facilities and results from the husbandry survey.

GORILLAS IN THE WILD

We recommend that exhibit design closely mimic the behavioral and environmental factors of the animals' natural habitat. As discussed elsewhere in this manual, the majority of research on gorillas has been on the mountain gorilla. From an environmental/behavioral perspective, the needs of mountain gorillas versus those of lowland gorillas may well be quite different, resulting in different design criteria. There are no mountain gorillas in captivity and few eastern lowland gorillas; as a result, this discussion will focus on western lowland gorillas.

Some surveys of the lowland gorilla have been conducted (Sabater-Pi, 1981; Tutin and Fernandez, 1983; Yuste, in prep), identifying habitat types and gorilla density in Equatorial Guinea, Gabon, Cameroon, and the Congo region (Cabinda enclave). In a 1994 ECOFAC study in Gabon (Stewart, 1995), four basic habitat types were distinguished: mixed forest with more or less closed canopy; Marantaceae forest (secondary forest with an open canopy resulting from regrowth on savanna); swamp forest; and forest bordering the savanna. In other studies, densities from .58 to 7.0 gorillas/km² were recorded, with groups of 2 to 30 individuals in home ranges from 200 to 5,000 ha. The highest densities were found in secondary forest habitats. Studies by Fay et al. (1989) in the Congo found, unexpectedly, that 98 percent of all nests surveyed occurred in swamp habitats (densities of 2.6/km²), most likely due to the abundance of natural food supplies. Before this study, swamps were not considered prime gorilla habitat. Therefore, previous extrapolated calculations based on known information of ranges and densities are now questionable.

In 1983, it was believed that lowland gorillas "generally prefer dense or secondary forest
and woodland to other habitats, but [are] characterized as an edge species found most frequently near roads, clearings, or fields in various stages of regeneration and [enter] mature primary forest, thickets, and meadows relatively infrequently" (Wolfheim, 1983). The lowland gorilla distribution relates directly to the regenerating forests that have resulted from rotational, slash-and-burn agriculture as this practice opens up the forest and allows for growth of herbaceous plants. Gorillas forage on these, as well as the crops. Roadside conditions are particularly important in whether or not the gorillas choose to feed along these sunny edges.

**GORILLAS IN CAPTIVITY**

**GENERAL DESIGN CHARACTERISTICS**

Any design process should include a "design team," made up of designers, builders, and all levels of institutional leadership. This team should be involved early in the design process and have continued input throughout construction and post-occupancy evaluation.

As described by Coe and LaRue in the *Orangutan Husbandry Manual* (in press), the tendency to write design standards as "problem-oriented" and not "opportunity-oriented" has resulted in a maximum security approach, which tends to eliminate enriching activities and pleasant surroundings. The scope of design projects tends to be defined by minimum standards of proven, built facilities rather than reaching toward innovation. Great ape exhibits have seen tremendous advances. The current state, however, is far from perfect. Only through evaluating the more fundamental issues and options related to design considerations can future facilities break new ground.

Lindburg (1992) notes that, for the great majority of species, "we must look toward a very long period of captive maintenance." To minimize the effects of captivity, the design process must consider the behavioral and environmental elements that can be controlled by the animals. The current trend is to consider gorilla exhibits as "life-care facilities," which should be designed to provide for the health and well-being of the captive primate throughout its long life span. Reintroduction to the wild may be neither appropriate nor necessary for this species. As a result, designers need to provide exhibits that include the elements and relationships that are found in the animal's natural habitat, creating facilities that will promote well-being in gorillas throughout their lives. The concepts of variability, choice, and environmental control are increasingly considered to be synonymous with environmental enrichment. These concepts must be maximized within great ape facilities.

**Viability of Mixed-Species Exhibits**

There has been little experimentation with mixed-species displays with gorillas. While there are some large indoor tropical enclosures that include free-flight areas for birds within the overall enclosures, few attempts have been made to include additional mammal species. At Apenheul, Holland, a group of patas monkeys (*Erythrocebus patas*) has shared a two hectare island habitat with two groups of gorillas (see Figure 1). Innovation in the design of the divider...
moat between the two gorilla groups utilized topography, water, and electric fencing in combination to create a safe barrier for the gorillas, while allowing the patas monkeys to pass
(Kopff and Mager, 1990). When considering mixed-species combinations, barriers need to be designed with the capabilities of each species in mind. When planning a gorilla exhibit, designers may wish to consider the possibility of eventually housing other species in the exhibit and design barriers accordingly. This will lead to a more flexible exhibit.

The Houston Zoo maintains a troop of guenons with a lone eastern lowland silverback gorilla, primarily to enrich his indoor environment. The National Zoo has maintained a troop of colobus monkeys with gorillas; again in an indoor exhibit. While the limited number of examples does not suggest it, the potential for mixed-species exhibits appears to be good with this species, given proper design considerations such as enclosure size, flight distance, environmental complexity, barrier safety for each species, and animal management facilities and access.

Defining Psychological Well-Being

In 1985, federal legislation was passed requiring facilities that house captive primates to provide for their psychological well-being (Animal Welfare Act Amendments, 1985). This legislation has resulted in a plethora of research studies and papers as professionals have struggled to provide operational definitions of psychological well-being in nonhuman primates.

Novak and her colleagues have provided a possible framework for discussing psychological well-being in captive primates (Novak and Suomi, 1988; Novak and Drewsen, 1989). They describe four measures typically used to evaluate well-being: behavioral markers like species-typical behavior, behavioral competence, stress, and physical health.

Species-typical behaviors: Behavioral markers, primarily the presence of species-typical behavior, are perhaps the most commonly used measure to evaluate well-being in captive animals (Novak et al., 1988; 1989). Simply put, individual animals are presumed to exhibit well-being if their behavior represents a profile similar to that of wild conspecifics. That is, behaviors observed in captivity should exist at frequencies similar to those in the wild, and behaviors not seen in the wild should not be seen in captivity.

Gorilla species-typical behavior is thoroughly discussed earlier in this volume. Typically, those using this measure focus on the presence of "desirable" behaviors, such as social behavior, and on the absence of "undesirable" behaviors, such as aggressive or abnormal behavior. However, as Novak and Suomi (1988) discuss, in using this measure animal managers must remember that species-typical behaviors are not always "desirable" in captivity. For instance, when gorillas meet in the wild, aggression often results between males that many zoo managers would find unacceptable.

Behavioral competence: A second measure of well-being may be how animals respond to changes in their environment, and how effective they are in their social relationships (Novak et al., 1988; 1989). Research conducted at Zoo Atlanta investigated how gorillas responded to new exhibits (Ogden et al., 1990). In an extreme case, one female never ventured farther than 20 feet into a naturalistic exhibit for the first two years on exhibit; her behavior could be interpreted as not representing well-being. In contrast, "Willie B," a male that had not been outside with other gorillas since he was wild caught at approximately three years of age, was subsequently
introduced to a new exhibit, then to females, and has since sired an offspring (Winslow et al., 1992). By these criteria, he could be presumed to exhibit psychological well-being.

**Stress:** The relative stress level of animals may serve as an indicator of psychological well-being (Novak and Suomi, 1988). Unfortunately, stress is neither easily defined nor easily measured. Physiological correlates of stress, such as corticosterones, may be measured, and corticosterones have been used as indicators of stress in a wide variety of species. Again, however, the relationship between stress/cortisol levels and well-being is not well understood. Primates in normal social groups may have higher levels of cortisol than do animals housed alone; however, they would not necessarily be presumed to have correspondingly lower levels of well-being than isolated monkeys.

**Physical health:** Physical variables, such as general health, have been proposed as indicators of well-being. Certainly, sick animals exhibit compromised well-being. However, as described by Novak and Suomi (1988), the reverse may not necessarily be the case. While health may be a necessary precursor to well-being, it may not be sufficient to indicate well-being.

**Promoting Well-Being In Captive Gorillas**

Gorillas require complex social and physical environs. Socially, there is evidence that young gorillas require the presence of both conspecific adults and peers in order to exhibit maximum reproductive and parental competence at adulthood (Beck and Power, 1988). As described in earlier sections on group composition, data from the wild indicate a wide range of group sizes. However, the Gorilla Master Plan recommends establishment of large groups, and there are anecdotal data to support the idea that large groups are conducive to reproduction and well-being. As described above, some zoos have even housed individual gorillas with other species in order to provide some social stimulation for these animals. In addition to social stimulation, gorillas in the wild live in a very complex physical environment, and it is thus the challenge of captive managers to mimic this physical complexity in captivity.

**Visitor Education**

Perhaps the single most important goal of zoological parks is that of conservation education. In addition to providing for the well-being of the inhabitants, the function of a gorilla exhibit is to educate the visitors. Visitor education often includes both formal programs offered to school and other groups and informal interpretation at the exhibit area. Further, many zoos are increasingly involved in assisting educational efforts in the host countries of certain species. In the best case, the visitors' experience of an exhibit affects them in three ways: 1) it enhances their cognitive understanding of the species and its circumstances, 2) it affects their feelings for and their awareness of the species and the environment, and 3), perhaps most important and certainly the most difficult, it encourages them to act: to do something positive for the environment.

Interpretation of the exhibit can be accomplished through a variety of media. The primary source of interpretation is the overall experience of the exhibit and the animals. A group of gorillas behaving in a species-typical manner, with appropriate interpretation, will provide the
guests with an accurate portrayal of the species.

"Landscape immersion" exhibits (Jones, Coe, and Paulson, 1976, cited in Coe, 1985), or aesthetically naturalistic exhibits, are those that strive to give visitors a more complete experience of the animals' natural habitat. While such aesthetics are of questionable importance to gorillas, they seem to be quite effective with our visitors. While visitors to traditional great ape exhibits generally spend an average of 1 to 2 minutes (Shettel-Neuber, 1988), visitors to the San Diego Zoo's naturalistic "Gorilla Tropics" (see Figure 2) exhibit spend an average of 10 minutes (Ogden et al., 1994). Similarly, these exhibits seem to increase positive emotion felt toward the animal inhabitants and their environment. Self-reported interest in conservation is also increased in visitors at landscape immersion exhibits (Ford and Burton, 1991). Visitors also seem to go away with a broader understanding of the intended connection between their experience and the animals' natural habitat.

Generally, informal interpretation is accomplished through graphics and signage. Unfortunately, as many zoo professionals are aware, signs are infrequently read by visitors. At San Diego's gorilla exhibit, approximately 13 percent of 600 visitors stopped to read large, visual-only graphic panels; these visitors spent an average of 31.4 seconds reading the panels. Certainly there are factors that can influence the numbers of visitors using graphic information. Interpretive panels that include any form of interactive element—from a casting of a foot that can be touched to a computer interactive—will generally increase usership and stay time. As an example, when life-sized bronze statues of gorillas were placed at the San Diego Zoo exhibit, visitors stayed an average of 79 seconds at these statues. These statues are also associated with increased learning about gorillas. Students who spent time examining and touching these statues exhibited increased awareness of gorilla social structure and physical characteristics (Ogden and Carpanzano, unpublished data). Similarly, visual-only graphics should emphasize pictures over words and should be carefully placed for visitor convenience.

Other forms of media, such as auditory interpretation, are increasingly being explored. Auditory interpretation may include: panels with push buttons to select an animal vocalization, a sound system that immerses visitors in pre-recorded sounds from an animal's natural environment, or a sensor-driven system that provides a narrative about an animal and its environment. Similarly, people (including keepers, docents or other interpreters) are increasingly called upon to present information personally to the guests. These types of interpretation, along with tactile interactives, are also useful for reaching often-ignored groups of zoo visitors, such as the visually challenged.

EXHIBITS AND OUTDOOR HABITATS

General History of Gorilla Facilities

The design of habitats for gorillas has had a diverse history. Starting with the first gorillas to arrive in England from the wild in 1855, physical conditions were not conducive for long-term health. In fact, most died within weeks, sometimes as a result of diseases carried by their human caretakers. Little knowledge about gorillas resulted in much confusion about the
animals' eating requirements, social structure, and taxonomy.
The first gorillas to arrive in the U.S. in 1897 died within five days. As a reaction to this and other historical experiences, a medically driven attitude was promoted in the handling of this precious cargo. Sterile enclosures with concrete substrate were built, devoid of materials that could be seen as carriers of disease. Improved sanitation created facilities modeled after hospital intensive care wards, with glazed tile and glass fronts to prevent disease transmission. As experience with interior exhibits increased, outdoor components to gorilla exhibits were slowly introduced. They were often similar to the indoor exhibits, except that they were open to the sky. The first successful gorilla birth in captivity occurred in 1956 at the Columbus Zoo, showing that through better understanding of the biological and physical needs of the inhabitants, gorillas could, in fact, be managed successfully in captivity.

With these sterile environments, however, boredom and stress were high. Human toys were used to encourage play behaviors, yet these exhibit features did not compare to the level of complexity and stimuli from their natural habitat, nor did they always promote species-appropriate behavior. Early examples of innovation during the 1950s and 1960s in San Diego, the Bronx, and elsewhere, included presenting animals outdoors, with sturdy playground equipment in moated exhibits. While these did not attempt to recreate their natural environment, they did advance the notion that the health of these animals could be maintained without a totally sterile environment.

As we became more experienced and as data from wild populations became available, additional advances were made. For example, gorillas began being exhibited in species-typical social groups, rather than individually or in pairs. During the 1970's, larger, more open environments were constructed, such as that at the San Diego Wild Animal Park. The gorilla exhibit in Houston (see Figure 3) and the Ape House in Krefeld, England, both opening around that time, used more naturally shaped forms for climbers and furnishings and surrounded the visitor in a green tropical foreground. A major contributor to the understanding of gorilla needs was made in the design of the Lincoln Park Great Ape House in 1977. It advanced a behavioral basis for exhibit design, providing abstract natural forms for climbing, nesting, and flight distance responses. This design gave the apes an enriched hard environment, plus access to an adjacent outdoor habitat; this combination and the increased choices proved successful in managing great apes in a captive environment.

By the mid-1970s, a new design philosophy--landscape immersion--was being explored in zoos (Jones et al., 1976). The concept of landscape immersion was first emulated in zoos such as Seattle's Woodland Park Zoo, embracing the notion that "an animal cannot be isolated, even conceptually, from the particular environment to which it has become adapted ...without a serious misunderstanding of its true nature" (Akeley, 1929). This approach, spearheaded by landscape architects and ecologists, strove to recreate, whenever possible, the natural environment of gorillas--both physically and socially. Through this approach, the visitor is offered a consistent message about gorillas and their behavior.

Continuing trends to build and manage multiple-habitat groupings have created dynamic experiences that promote species-appropriate behaviors. With these multi-group displays, the full range of inter-group behaviors are encouraged (e.g., Coe and Maple, 1984). In some cases (e.g., Dallas Zoo, Zoo Atlanta), provisions were made to consider the possibility of allowing females to migrate to the other troop, on exhibit, as they become sexually mature.
Containment Barriers

Containment is a primary exhibit shaper and represents the most expensive portion of an outdoor exhibit. Gorillas are neither great jumpers nor great acrobats, but they are strong and agile climbers. Each institution should determine minimum barrier dimensions and maintain these consistently throughout. Aesthetic considerations may encourage some variation in height (see Survey Results section for dimensions currently used by respondents).

Combinations of barrier types can be employed, depending on factors such as site conditions, construction access, viewing opportunities, and landscape replication. While not necessarily continuous by type, barrier dimensions should be continuous around the animal's perimeter. In selecting barrier types, it is important to consider their varying psychological impact on the confined animal. The perception of available space can be enhanced, as can the ability to escape from public view.

The concept of "flight distance" must be considered in enclosure design (Hediger, 1968). There must be adequate depth and visual cover for the animals to establish their own minimum distances. These distances must be figured for each human and gorilla interface. Reducing the intrusiveness of viewing opportunities should reduce flight distance at these areas (for example, by heavily planting viewing areas).

Containment barriers can be classified into a limited number of types, with selection based on cost, function, and viewing distance/aesthetics. Four types are used successfully to contain great apes: 1) walls, 2) moats, 3) mesh structures, and 4) glass walls or view blinds.

Walls

The goal, obviously, is to create non-climbable walls. Texture must be relatively smooth to prevent foot or finger holds. Overhangs may be added to prevent scaling. 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. Rockclimbers 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 rockclimbers.

Advantages of walls are that they take up very little room and are less costly than moats. The disadvantage is their visibility, which is usually disguised with geologic textures (rockwork), painting techniques, and heavy/protected planting, thereby increasing their cost.

Moats

Moats are typically parallel walls spaced at the barrier distance, with the outermost wall set at the barrier height. They can be either wet or dry. Shallower, wet moats have been used with gorillas (Apenheul; Philadelphia--with hotwire), but there are potential safety problems; thus their use should be limited. Field research has shown that gorillas in the wild do not ford deep water and are not able to swim. The dry moat is clearly the safer approach.
The exterior wall (public side) of the moat must be unclimbable, while the inner wall (animal side) may be textured, or in some cases the animal side is a planted slope (Dallas, Busch Gardens, Denver). When oriented perpendicular to viewing areas, moated barriers are nearly invisible, thereby enhancing the visitor’s experience.

In the design of the moat, it is often structurally efficient to use the bottom of the moat as the foundation of the parallel walls. If this is done, the bottom of the moat should be filled with a resilient material (e.g. soil/turf) to absorb the shock of accidental falls. Safety cables, rails and even chainlink trampolines have been used in specific locations to reduce the risk of falls into dry moats.

It is good practice to prevent runoff between exhibit areas. Well-designed moat systems can be integrated with the sanitary run-off from the exhibits, creating a more ecologically balanced approach to storm water retention and management. Drainage studies must be undertaken to direct water runoff within the system and to provide adequately sized drainage structures.

Barrier dimensions need to consider topographic variation, especially in relation to moats. One common method for maintaining the appropriate barrier distance is to ensure that a distance the height of the barrier wall is maintained from all adjacent surfaces (i.e., "radial distance"). As an example, if the barrier wall is 12 feet high, no object in the exhibit that could be used to facilitate escape (such as a tree or a hill) should be less than 12 feet from the wall.

When concealed dry moats are used, both the visitor and gorillas must be protected from them, visually and physically. On the gorilla side of the moat, some institutions have used hot wire, pipe rail, or deadfall to warn them away from the edge of the moat. The use of sloped moats may provide a better alternative or can be used in combination with vertical wall surfaces.

Moats are typically more expensive and put more distance between animals and visitors. With multi-group exhibits, double moats should be used between groups. The space required by moats is especially a concern when little space is available for the exhibit, because moats will take up space that could otherwise be available to the animals.

Steel Mesh Structures

Steel mesh enclosures can be large outdoor cages with 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. To minimize gorilla-visitor contact, 5-centimeter (2-inch) openings have been used, with people approximately 2 meters (6 feet) behind secondary barriers. With larger mesh openings, 10 to 16 centimeters (4 to 6 inches), visitors should be kept 2 to 3 meters (6 to 9 feet) away, as the animals will be able to reach their arms through the larger mesh openings. It should be noted that some veterinarians recommend a 15-foot distance to reduce the potential for disease transmission.

There are many forms of mesh available with advantages and disadvantages to each in

234
viewing and structural characteristics. In smaller exhibit areas, these enclosures with accessible sides and ceilings allow the animals to use more of the volume of the exhibit. Further, because furnishings such as trees cannot be used as escape methods, this barrier increases the flexibility with which such furnishings can be used. While the posts and beams (or cables) are more intrusive to the viewer, they may be disguised with tree forms and perimeter plantings. Some zoos have been successful using fences with solid overhangs (e.g., Lowry Park) or expanded metal with mesh too small for gorillas to climb (e.g., North Carolina Zoo, Little Rock Zoo).

Viewing Blinds

More than 50 percent of those surveyed use glass walls as barriers in order to provide close-up visitor experiences. Glass is best combined with viewing blinds, because as glass is exposed to direct sun, reflections can obscure viewing. Darkened visitor shelters provide a glare-free environment for the viewer; glare should be controlled on the animal side as well by extending overhangs.

Because any thickness of glass is potentially breakable, consideration must be given to access for replacement. Acrylic panels are less breakable, but scratch easily. Structural characteristics must be determined by glass specialists based on the size of openings and assumed loads. Barrier heights must be determined from any horizontal member to the top of the wall. Other considerations when dealing with glass are the color or tint and the possible use of one-way glass.

The design of the Dallas Gorilla Exhibit took the concept of non-intrusive viewing a step further. One-way glass was used in the viewing "bunkers," camouflage netting was used in moat blinds, and an array of video cameras and monitors was used in the interpretive building to allow visitors to observe the animals in out-of-view areas of the exhibit (see Figure 4). Further, plants were used in the holding building between dayrooms and keeper areas to screen the animals from the caretakers (Bruner and Meller, 1992).

Carefully controlled, high-quality viewing conditions can help reinforce the message of respect for these animals. However, these visual gains may be offset by the loss of auditory and olfactory input.

Secondary Barriers

High voltage electric fencing has been used successfully in gorilla enclosures to: 1) maintain protection around vegetation areas, 2) discourage use of moated/out-of-view areas, and 3) as insurance on top of barrier walls and fencing. In a survey of 94 institutions (representing 89 percent of institutions housing captive great apes) (Ogden, Bruner, and Maple, 1992), 50 percent used electric fencing with at least one great ape species, but only two used it as a primary barrier (and later discontinued its use). Compared to other great apes, gorillas rated highest in "avoidance" response and lowest in "tool use" associated with electric fencing, thus demonstrating its success as a secondary barrier for this species.

Physical Complexity and Furniture
There is obviously more to an outdoor exhibit than the containment barrier. In order to elicit species-appropriate behaviors from exhibited animals, there are a host of furnishings that
should be provided to replicate objects found in the gorilla's natural environment (also see Enrichment chapter in this volume).

The use of live and dead plant materials is generally considered to be the most useful furniture in outdoor enclosures. Vegetation provides shade/cover, display and foraging items, browse/food elements and nesting materials, and allows for visual cover from other animals, thus promoting species-appropriate behavior conducive to both the apes' well-being and the visitors' education. Various rock outcrops, artificial or natural topographic features, and deadfall trees can be arranged in a manner to encourage natural movements and locomotion patterns within the exhibit, to simulate the daily foraging behaviors of wild gorillas. The placement of exhibit furniture, and the planting of islands and climbers, teamed with barrier and view conditions, can create a dynamic outdoor environment for both apes and visitors. As a caveat, any moveable piece of furniture must be used carefully; gorillas have used branches as ladders to escape from exhibits (e.g., Woodland Park Zoo).

A later section on horticulture goes into detail concerning the management of a living landscape. As it relates to this discussion, protection of existing and planted trees provides the basis for developing long-term, sustainable environments. Provision of browse for nest building, establishing plant enclosures protected by electric fencing, fiberglass bark wraps, and other forms of tree protection allow the animals to use but not destroy the furniture that provides the most appropriate elements for well-being. In general, experience has shown that, sooner or later, gorillas will kill unprotected trees.

Physical complexity certainly includes elements such as size of the exhibit and exhibit furnishings. Clearly, exhibits should be as large as is economically possible; large exhibits generally provide more extensive furnishing opportunities and allow for more complexity of space. However, quantity of space alone is unlikely to provide for well-being. As an example, it has not been a factor with closely related species such as orangutans (Perkins, 1992). On the other hand, complexity of space has been clearly identified as related to activity and well-being in a number of primate species (e.g., orangutans: Tripp, 1985; Perkins, 1992). Complexity of the environment is largely synonymous with its variability, and thus can include seasonal variations, shade/sunny areas, and variations in texture and substrate, as well as specific furnishings. Key components of well-being are environmental control and choice. Having variability inherent in the landscape equates to having choices in that landscape, thus allowing the inhabitants daily choices.

A study of enclosure use by 24 gorillas, in 6 different groups, provides some data on desirable structural variables in gorilla exhibits (Ogden et al. 1993). In general, while some topographical variability is recommended as it promotes a variety of species-typical behaviors, lowland gorillas seem to prefer areas that are flat. Further, gorillas significantly preferred areas including at least one piece of furnishing (e.g., climbable trees, plants, deadfall, rocks, streams), over empty areas and preferred items that they could lean against.

Physical complexity also relates to how animals and their exhibits are managed. As stated in the earlier chapter on enrichment, a key component of environmental enrichment is novelty. For example, some zoo professionals are beginning to recommend rotating animals through exhibits as a way of stimulating novelty (e.g., Coe, 1995). Fried et al. (1993) found that rotating
gorillas through exhibits had positive effects, as did other forms of complexity, such as plants. Lucas (1995) reported similar results. When designing exhibits for gorillas, care must be taken to design elements that will allow the animals to exhibit their full range of species-typical behavior. For instance, plants, deadfall, or other objects that can be used for bluff charges are necessary, as are items for use in play. Exhibits must be designed with a variety of sex and age ranges in mind. For example, adults utilize display and nesting items; younger subordinates need to escape the attention of adults; infants need to play. The exhibit should be large enough and/or have enough visual cover to allow animals to feed with some distance between themselves, as they do in the wild.

**Behavioral Enrichment Areas/Devices**

Exhibit design must permit the staff to manage enrichment within the enclosure. This includes developing planting strategies and protection systems, providing feeding devices or food placement opportunities, etc., as well as allowing evaluation of enrichment strategies.

Although it has been noted that gorillas are primarily terrestrial primates, given the opportunity, they will climb and use trees. Artificial climbers provide for some of the range of locomotion and behaviors displayed in natural trees. Wide, comfortable crotches for perching and well-placed branches for climbing can be designed into the form of artificial trees. However, some of the more subtle qualities, including flexibility, shade, manipulation, destructibility, and food source, may not be provided by artificial trees. Difficulty related to long-term stability, cost of materials and natural forces tend to create artificial trees that can only provide a limited range of qualities. Combinations of climbing structures, artificial and dead trees, vines, ropes, and wooden constructions may promote a wider array of behavioral options for expanding vertical and horizontal dimensions to habitats. Whenever possible, enrichment features should be serviceable from outside the enclosure. As examples, trees and climbing structures should be easy to replace, and it should be possible to restock feeding stations from outside the exhibit, so that they can be restocked throughout the day if desired.

**Public Viewing/Viewing Level**

The design of public viewing spaces shapes the experience of the exhibit for the visitor. Variation in viewing heights and sightlines into borrowed landscapes all allow the designer to communicate the landscape and animals to the visitor. Many zoo designers (in particular, Coe, 1985) feel that viewing animals from below increases the respect that visitors feel for them, whereas looking down on animals leads to a feeling of superiority over animals. Distracting views of objects that detract from the ideal vistas should be eliminated or masked and can be determined through carefully studying the sightlines and grading.

The design of viewing rails plays heavily in the experience of an exhibit. Again, to protect the visitor, many considerations need to be reviewed. These include: legal requirements based on local safety codes, stroller and wheelchair viewing, ADA requirements, and other standards. Ideally, viewing conditions should provide visual access to the exhibit while not negatively impacting the animals’ comfort or creating dangerous conditions for the public.
Other options available relate to the thematic considerations for the visitors experience. "Gorilla museums," "research stations," or "interpretive centers" combine viewing opportunities with interpretive graphic materials to add new dimensions to the passive viewing condition. Viewing situations that further immerse the visitor into the landscape can include the use of canopy walkway systems, viewing observation decks, or viewing blinds, such as through a thicket or a cave-type structure.

**Landform and Topography**

The increasing use of natural substrate has added complexity from an animal health perspective. While soils can be tested for parasites, or assessed for pH value, etc., we have no general standard that can be measured and monitored for animal health requirements. Some concerns to consider on a case-by-case basis are particle size/water drainage, rocks, and other hazards. In particular, rocks may be of concern where glass windows are used, as rocks have been used by some species as tools to break glass (e.g., San Diego orangutan exhibit).

These outdoor exhibit areas are best seen as recreations of actual landscape types, with those elements found in that landscape. Leaf litter, exposed roots, thickets, brambles, marshes, packed earth, and cultivated field are examples of the complexity of substrates used to recreate the landscape types that would be found in the wild equivalent. The majority of institutions are now using natural substrates with gorillas (36 of 39 responding institutions). The effect of soil type on compaction should be considered (e.g., soils heavily made up of clay are more easily compacted than soils that are predominantly sandy).

The use of water in plant communities should be replicated as well. While there is a tendency for gorillas to avoid water, the use of shallow water features in exhibits has been shown to provide additional stimuli for species-appropriate behaviors and in some cases has been utilized to protect plants. While the use of water is typically limited to drinking, touching, or play, these behaviors can be exploited. Captive gorillas have been reported to immerse themselves in shallow pools, adding enormous sensory experience to their routine. The introduction of water in streams, pools, and waterfalls adds a tremendous dimension to the daily environmental experience for both gorillas and visitors. Substrates for water must be safe for the impact from gorillas; concrete and clay liners should be used, rather than plastics and rubber.

Safety concerns related to natural substrates must be addressed, especially within the construction process itself. Limited access by the contractor in areas of natural topography around existing trees and vegetation should be maintained. Removal of construction debris must be monitored constantly, with strict controls. Fine grading and magnetic pick-up of bolts and metal objects must be given appropriate effort prior to animal move-in. As soils mature, objects tend to migrate upward, revealing themselves over time; thus daily monitoring should be part of the pre-release routine by the animal caregivers.

On sites with existing, mature shade trees, careful decisions need to be made early in the design process concerning the long-term health of the trees. While the advantages of maintaining existing shade trees cannot be argued, moats and other heavy construction adjacent to mature trees can have devastating consequences. Compacted filling or excessive cuts can destroy the...
tree's root system far beyond the spread of the tree's canopy. Protection of existing tree areas should dominate the design effort. A professional arborist should be consulted early in the design process.

The design of barriers (moats and walls) and routing of utilities within an existing woodland/forest has a dramatic impact to the health of the woodland, changing drainage patterns and limiting root space. Careful placement of site features around existing forest stands must be of primary concern if the long-term health of the natural area is to be maintained.

Horticulture

In captive situations, using plants in direct contact with animals requires balancing both botanical and zoological aspects. It is important to make the connection that, just as a captive animal needs care, so does a plant. Successful management depends on a close working relationship between those who care for the plants and those who care for the animals, as the practices and techniques of one will constantly affect the other. Basic plant needs have to be met or the plant will die. Captive situations allow for repeated overuse without time for recovery. On-going mitigation of this overuse is needed.

It is important to know specific animal behaviors elicited by plants to determine plant selections and plant maintenance schedules. Depending on a particular animal, it may eat just the leaves, stem, or pith. Different plants or plant parts may be used at different times of the year. In addition to feeding, gorilla behaviors involving plants might include playing, nesting, hiding, and social interactions such as displaying/bluff charges.

Gorillas tend to stress plants in three main ways:

1. Mechanical injury: animals will eat, break, pull up, or otherwise cause physical damage to plants.

2. Soil problems associated with animals: compaction (loss of air in the soil or breakdown of soil structure); soluble salt build up from urine or feces accumulation.

3. Indirect damage: for example, inability to isolate a diseased or stressed plant from animal interaction; insect or disease infestation.

Following are some techniques and "rules of thumb" that may help provide a sustainable gorilla landscape.
1. Start with good soil conditions, amend as necessary.

2. Match the number of animals to the carrying capacity of an exhibit and/or size the exhibit to the number of animals eventually to be housed on the landscape.

3. Reduce steep-sloping topography. Even normal use of such areas causes plant damage or erosion.

4. Use the best horticultural practices when selecting, digging, and planting materials. Match plant types to existing growing conditions or provide growing conditions for the plant types chosen.

5. Overplant species used by the animals. For instance, use a higher seeding rate than normal, plant more plants with a denser spacing, or in the context of all the plants used in the exhibit, use a larger percentage of plants used by the animals.

6. Use plants with aggressive growth rates wherever possible.

7. Plant different types of plants to elicit different behaviors.

8. Use plants that may not be as prone to damage; for instance, plants that taste bad, have extremely hard or supple woods, or have natural defenses such as thorns.

9. Provide adequate establishment time for plants. An established plant can withstand more use than one not established. Larger-sized plants tend to fare better and last longer, yet take longer to acclimate.

10. Protect plants during establishment or recovery periods, or even on a permanent basis.

11. Provide additional browse/enrichment items to reduce stress on the planted landscape.

12. Rotate animals on and off a planted area to allow recovery time. This concept is similar to pasture rotation with livestock, and could be accomplished through multiple planted areas, compartmentalization of the exhibit, or adequate non-planted spaces for exhibit/holding while the planted area is recovering.

13. Provide optimum ongoing horticulture care and optimum conditions for such items as fertilization, irrigation, and insect and disease control.

Exhibiting plants and gorillas together increases the risk of exposure to toxic elements. Knowing which plants are toxic and under what conditions becomes immeasurably important to an animal's safety. This can be difficult; simply because a plant is or is not listed in toxic plant references is not a clear indication of toxicity (Kingsbury, 1964), particularly to another species.

Both success and failure are part of the learning process. Even successes can create
difficult cultivation problems. Stimulating gorillas to exhibit natural behaviors generally results in additional plant damage. Zoo horticulture relies on continual vigilance and perseverance, willingness to experiment, and extrapolation of information from related sciences.

Exhibit Size

There is no set formula for determining the size of an exhibit; however, there are a number of factors that can be used when determining the size and shape of an exhibit.

1. Group size and composition; including the optimum group size and composition, age distribution, sex ratios, and group dynamics.

2. Space needed for species-appropriate behavior, displays, self-imposed isolation, and sub-group formation.

3. Distance between the human access interface and the retreat zones of the exhibit that allow animals to regulate individual spacing.

4. Specialized foraging areas for a wide range of locomotive and feeding behaviors.

5. Distances between barriers and climbing structures/trees.

6. Space for fallow areas and planting islands for landscape re-growth.

7. Relationships between other exhibits and other species within a mixed species' enclosure, or other species that you might eventually want to house in this exhibit.

8. Space needed to provide enough landscape to provide an experience of the gorillas' natural environment.

9. Topographic relief or variation to create different micro-climates for various uses, throughout the course of a day.

While bigger is not always better, there is a trend towards larger, more complex exhibits. The early innovative exhibit for gorillas at the San Diego Wild Animal Park, built in 1975, was 1215 sq. m. (13,500 sq. ft.) compared to the original San Diego Zoo 527 sq. m. (5,850 sq. ft.) grotto exhibit. As newer exhibits are being planned, considerations for multiple habitats or exhibit clusters have been advanced.

In 1988, the "Gorillas of Cameroon" exhibit opened at Zoo Atlanta (see Figure 5). This exhibit includes five separate habitats ranging from 300 sq. m. (3,000 sq. ft.) to 2,100 sq. m. (22,600 sq. ft.) [average: 1275 sq. m. each (13,750 sq. ft.)], for a total of 6385 sq. m. (68,732 sq. ft.) of habitat. Together with a 1300 sq. m. (14,000 sq. ft.) holding building interconnecting each habitat with full integration of night quarters, shifts, squeezes, and dayrooms, this exhibit illustrates the concept of a "life-care complex" for an ever-expanding population of gorillas.
within a singly managed facility.
"The Great Escape" at the Oklahoma Zoo, opened in 1994, contains two gorilla enclosures at 2500 sq. m. and 1335 sq. m. (27,000 sq. ft. and 14,375 sq. ft.) and additional single habitats for orangutans 600 sq. m. (6,530 sq. ft.) and chimpanzees at 1486 sq. m. (16,000 sq. ft.), with a common holding building containing interior dayrooms/night quarters and interpretive galleries (see Figure 6. See also diagram of Busch Gardens exhibit, Figure 7).

At the Wildlife Conservation Society's Bronx campus, "The Congo Gorilla Forest" is currently being designed. Its early program includes two spacious, moated gorilla enclosures at 2090 sq. m. and 2622 sq. m. (22,500 sq. ft. and 28,225 sq. ft.). The interior habitat includes a 117 sq. m. (1,260 sq. ft.) "natural habitat" day room, night quarters for up to 30 gorillas, a quarantine facility, and a multi-level "Great Ape Gallery" with 280-degree views into the exhibits. Interpretive concepts encourage conservation education and action, focused on actual WCS projects in the wild. These types of projects point to the direction in which great ape facilities are moving.

Exhibit Access

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

Early planning for the service or utility side of the exhibit should include items such as water run-off, irrigation systems, and the design of water features. Whenever possible, it is wise to keep all pipes and utility structures (e.g., drains, irrigation values, and heads, pumps, etc.) outside of the animal enclosure. Not only will this aid in the service of those systems, but it will prevent the possibility of animal damage. Where drains are required (e.g., low points in moats, in water features, etc.), grates should be bolted down.

Security lighting and provisions for power and water need to be accessible to keepers and maintainence personnel, but not to the animals. Mesh keeper-access vestibules are sometimes convenient places for organizing these elements while providing safe keeper access.

**Animals:** Regarding animal access into an outdoor exhibit, preferably more than one animal door should be provided to prevent one animal from denying access to others. When locating these doors, most designers go to great lengths to screen them from the public; however, it should be noted that Ogden et al. (1992) found that the majority of gorillas in the study spent considerable time in the area adjacent to the holding buildings. Either these spaces should be made visible (while somehow still screening the buildings) or they should be made less appealing as rest areas, such as by steeply sloping them.
Bio-Climatic Control

The comfort range for these tropical animals is between 20-30 degrees C (69-86 degrees F), but with gradual acclimatization, many tropical primates can tolerate outdoor temperatures down to 0 degrees C (32 degrees F) on sunny days. Wind protection, sun pockets, heated perches (disguised as rocks or logs) in winter, and shaded resting places under protected trees or north side of structures/walls in summer, allow the animals to have access to a wide range of temperature variation. Elements such as heated perches, shade, and sun pockets should be carefully placed in an exhibit to maximize viewing opportunities.

As management permits, gorillas should be given the option to enter heated shelters of indoor habitats when they desire additional warmth. By balancing the indoor temperature with the outdoor, daily fluctuations can be limited, as long as there are the necessary mechanical system controls. Depending on the sites' micro/macro climate, adjustments should be made to maintain balanced temperatures between habitats. Of course, the focus should be on balance, not on matching indoor temperatures with an extremely high outdoor temperature, for example. Some designers recommend a maximum variation of 10 degrees C (approximately 20 degrees F) between indoor and outdoor temperatures.

Observation/Evaluation

Continuing efforts to understand gorillas have inspired thousands of hours of observation by trained observers throughout the world. The ever-expanding supply of studies and papers presented at a wide range of scientific forums confirms the need to plan for research within the facility. Various forms of research are being carried out at today's zoos--space utilization, behavioral studies, feeding and nutritional studies, fertility and developmental studies, pre- and post-occupancy studies, and visitor attitude studies--looking at what the exhibits communicate to the public.

As noted in the survey section, 81 percent of the gorilla facilities reported having a research observation area for the overall facility and 43 percent in outdoor exhibits only. The issues involved are simple and straightforward. As presented in the *Chimp Husbandry Manual* (Fulk, 1992):

1. It is important to provide an observation area that has a clear view of an entire exhibit or holding area. In many cases, multiple observation areas will be required to view the entire exhibit area.

2. Concealing observers from the gorillas is important to eliminate any interactions between the observer and the animals that may affect the data. This can be accomplished by using remote cameras or a blind. Blinds can range from the elaborate and costly to the simple use of vegetation as a visual screen.

3. Giving observers a place that is separated from visitor overlooks will allow them to devote their full attention to what they are doing. On the other hand, properly trained observers can be used to educate visitors about the species, individual
animals, and the institution's commitment to the gorillas and conservation.

Zoological research has inspired partnerships with scientific and education institutions throughout the world. These partnerships have provided tremendous benefits to both parties in synergistic ways: grant funding, research staff loans, technical support, and other resources.

INDOOR HABITATS

Classification System

The types of indoor habitats for gorillas can be subdivided into four generalized types: 1) night room; 2) shift room; 3) day room; and 4) special rooms.

Night Room and Shift Room

The night and shift rooms are the primary holding units for gorillas and are generally off exhibit. These rooms should be arranged in a series, to allow a rotational connection to the outdoor habitats as well as to day rooms and special rooms in such a way that any animal can be shifted from any room to any other room within the system, without anesthesia. The night room should be outfitted with sleeping platforms, hammocks, and other soft replaceable materials for bedding to provide a dry and comfortable resting environment, as well as multiple provisions for ad lib water. The shift room(s) provide a secondary room to shift the entire group while the keeper staff cleans the night room. The night and shift rooms can be used as a day room suite, if the group could not be transferred to either the real day room or the outdoor habitat. The shift room can be significantly smaller than night rooms, if necessary.

Day Room

The day room (or community room) is sized to accommodate the extended family unit, and may or may not be used for public viewing. Day rooms range from environments that are quite natural in feel and appearance, including soft substrates, landscape materials, and artificial rockwork, etc., to more functional rooms that are larger versions of night rooms, with additional props to promote species-appropriate behaviors. Both must be highly complex environments designed to provide novelty and exploration for the gorilla in a climate controlled indoor environment. The use of visual barriers, topographic elements, perches, climbers and other furniture in these rooms may help to encourage positive behaviors in what is generally a more confined indoor environment.

Day rooms should have provisions for natural light through (protected) skylights/windows (see below) and, if possible, fresh air and direct light through operable skylights/windows (especially in cold climates and short-access exhibit days). These range from the Zoo Atlanta/Dallas size, (65-70 sq. m.; 800 sq. ft.) to Busch Garden's (200 sq. m.; 2100 sq. ft.) day room.
Special Rooms

There are many "special rooms" in animal holding areas; many perform multiple functions and can be combined as desired in the design of the indoor habitat. The following represents a range of functions that need to be considered in the design of the "life-care center" for gorillas.

**Quarantine facilities:** Prior to transfer to a new location, gorillas are subject to Federal Guidelines for quarantine requirements. Depending on the population of great apes at any given institution, it may be wise to build and maintain a Center for Disease Control (CDC) rated facility adjacent to the general holding area. The CDC's requirements must be followed in strict conformance to be approved and to maintain status.

If the quarantine facilities are provided within the overall holding facility, care must be followed to separate completely the life support functions (i.e., plumbing, drainage, air ventilation, etc.). Special "clean-room" level seals may not be economically feasible, yet thoughtful detailing supported by properly sized mechanical systems (operating with negative pressure) can maintain zone lines between separated systems.

Consideration needs to be made regarding strength, durability, and redundancy in the design of quarantine facilities. For example, can you afford to "re-set the clock" if you have to replace a broken skylight? These facilities should be designed to allow for use by a wide range of species, with varying size and strength requirements.

**Introduction suites:** As a new member prepares to migrate into a group, special introduction areas facilitate this safe and monitored periodic event. Introduction areas can consist of two rooms, with an adjoining double wide mesh "howdy" wall (≥6" between mesh), to allow touch, smell and sight, but not grabbing and biting. A transfer door is used to complete the introduction, when the stress level subsides. The opportunities for enrichment/play devices within the howdy wall mesh frame are endless and should be exploited. The design of these facilities should include the capability to create a circular pattern of movement between rooms and should not include places where individuals can get trapped.

**Medical areas:** Separated medical areas should be provided within the general holding area for those individuals needing special immediate care. "Every effort should be made to design in ways that bring medical treatment to the animal, instead of the reverse" (McManamon and Bruner, 1990). By moving the animal out of its normal environment, added stress resulting in the move may jeopardize the outcome of the treatment. Specialized features built into the facility may increase cost yet can greatly enhance care.

McManamon and Bruner (1990) suggest (for orangutans) the medical area should--at minimum--be a room with equipment for examining animals, taking blood samples, suturing wounds, and other minor surgical procedures. Emergency equipment should be available (oxygen, EKG, heat lamps, immobilization equipment). The size and complexity of this area depends on the size of the animal population it is serving.
**Nurseries:** Hand-rearing of neonates is not recommended; however, a nursery area is sometimes necessary due to unsuitable mothers or lack of surrogates. Nurseries, hand-rearing suites or portable modules have met with success; ideally, they should be situated within visual contact adjacent to the holding area of the natal group. These areas should permit easy access to the infant for feeding and care while still being within the holding area. This permits early exposure to the sights, smells, and sounds of future family members and provides accelerated learning of behaviors. Interconnected passageways that are sized for the youngster provide access when integration occurs (Lindburg and Coe, 1995). Even if a stand-alone nursery is present, the holding facility should have introduction facilities suitable for early socialization of neonates.

**Specialty cages:** The squeeze cage is a confined cage (generally ≈2m x 2m x 2m) with an additional moving wall that directs and maintains an animal to one side wall where close examination and medical procedures can be undertaken. These are designed to examine gorillas without invasive or hazardous means and for quick, efficient capture and restraint. They can be either built-in to the sequence of cages or used as a plug-in, portable unit. The built-in variety has the advantage of being part of a daily routine and not being associated with a particular stress event. In this case, transfer doors lead into and out of these cages and into the general holding rotation.

The collection cage is similar to the squeeze cage except that it has an elevated mesh floor. This cage type is used to monitor the animals' intake and output over time and to facilitate fluid collection. The solid "lower" floor should be isolated from other area drainage and sloped to a single point where a collection pan can be inserted to collect fluids. Attention must be given to the most appropriate collection devices for particular needs. The elevated floor should be high enough to adequately clean the lower floor and should match the height of the transport box.

Provisions can be made to connect a transport box to these squeeze cages through an intro door by inserting a manual guillotine gate (sized to match the transport box with matching padlock tabs), into the keeper gate of the squeeze. As an example, the transport box used for gorillas at Zoo Atlanta is .82 m W x 1.0m H x .91 m L (27" W x 39" H x 36"L). It is combined with an adjustable rolling cart for ease of connection and mobility.

Overhead transfer chutes are used to provide linkages from one space to another or across keeper corridors. These are typically 1m x 1m (3’ x 3’) with mesh on all sides. Care should be given to provide adequate clearance under chutes and to restrict use of spaces under these chutes. It should be noted that a very common design problem is a lack of coordination between building mechanical systems (principally air ducts) and overhead transfer chutes. This may result in the chute needing to be lowered to such a point that head room below the chute is restricted.

Weigh stations should be provided within the caging system. These can be, again, built-in or portable depending on the location. Weigh stations have been associated with transport cages, collection cages, and overhead transfer chutes with equal success.

**Training considerations:** Consideration for training opportunities should be designed into all facilities. Laule (1995) recommends, "good visual access for keepers to animals...multiple access points for interaction, built-in mounts for husbandry apparatus, good
lighting and multiple and connected off-exhibit spaces with no dead ends for enhancing introductions and supporting easy separation of socially housed animals."

**Other considerations:** The boredom inherent in hard-surfaced areas with easily sanitized surfaces may make enrichment more difficult. Every effort should be made to dampen harsh sounds and vibrations (see section on sensory environment). Rubberized floors have been used successfully with species such as rhinos; such floors might serve to soften the environment while still being easily disinfectable.

Including video monitoring devices and access for conduit in the early design of these areas will be wise even if there are apparently no funds for equipment.

**Keeper Service Areas**

Other things requiring space in the indoor habitat relate to the keeper environment and support areas. These areas should be functional and comfortable while being cleanable and secure (see discussion on pest control). Basic functions need to be programmed for:

1. Keeper locker rooms to allow staff to shower and change as necessary to prevent disease transmission.
2. Record keeping/reference materials/office space.
3. Research areas should be provided related to the degree that research is done at the institution. These areas ideally should be easily accessible to non-keeper staff (i.e., behavioral observers should not need to enter a restricted primate area to view a videotape monitor). Because of the current body of literature on gorilla, and the improved conditions of the species in captivity, research will likely continue in the future.
4. Space must be provided for food preparation and storage of food, supplies, equipment, and tools.

**General Design Elements**

In this discussion, we suggest that interior habitats are made up of a variable number of specific rooms, each with a programmed use and arranged in a rotational sequence to allow maximum flexibility for the gorillas and ease of use for the care-givers. Indoor quarters may easily be hard, inflexible, and devoid of novelty. Alternatively, large dayrooms have been built with many props, extensive skylights, and artificial lighting. While these rooms have greater application in cold climates, they can add great flexibility to any facility. By adding elements within the habitat that either replicate the natural world or provide the same sorts of stimuli in a man-made context, these spaces provide year-round environments for captive primates within a climate-controlled space.

**Containment:** For basic containment within the interior habitat, materials need to be
cleanable, non-corrosive, securely attached, and dependable over time. Poured-in-place concrete has been the material of choice in most cases. While masonry units/glazed block etc. have been used extensively, mortar joints require sealing and long-term care. Most indoor facilities are designed with concessions to sanitary considerations and the high cost of construction; thus they tend to be smaller than needed and more sterile than desirable from an enrichment perspective.

By using materials and enrichment items to provide variability and novelty within a sterile shell, innovative indoor habitats have been created that promote species-appropriate behaviors without the use of natural environmental elements. Considerations need to be made for de-mounting and re-propping these rooms without affecting the overall containment walls, floors, and ceilings.

**Size/number:** Determination for the size and number of separate rooms is highly complex and variable, depending on institutional goals. Because of the troop living social structure, night or day rooms should be large enough for multi-member groups to share one or more rooms. If density is too high, aggression towards other group members and damage to the facility will need to be monitored.

At Zoo Atlanta, for the five groups of gorillas, there are two night rooms 30 sq. m. (16' x 20' x 10' high) per group, plus additional shift rooms, transfer cages, etc., available. A day room, 65 sq. m.: 8 m. x 10 m. (720 sq. ft.: 20' x 36'), introduction suite, three squeeze cages, plus an adjacent quarantine area is also part of the facility (see Figure 8).

At Busch Gardens, for one group/one exterior habitat, there are six night rooms (approximately 35 sq. m. each; 400 sq. ft.), with additional introduction, isolation and two transfers, wrapped around a 200 sq. m., 8 m. x 26 m. (2236 sq. ft., 26' x 86') skylighted dayroom (see Figure 9).

Shape and internal amenities rather than size and number has been shown to be more important in the behavioral benefits of an indoor habitat (Erwin and Deni; 1979, Maple and Finley, 1986). The ability to alter and modify the environment will promote more desirable behaviors and reduce stress within the group.

Hediger (1968) described the basic cube design as the most un-biological of all shapes, yet the majority of indoor habitats currently use this shape. This relates to an unfortunate design trap that identifies straight walls with cheaper walls. New technologies coming out of exterior exhibit construction (gunite and shotcrete) have shown the plasticity of concrete to take many shapes.

**Structural frame, surfaces, and substrate:** Containment in the indoor habitat is defined by the structural frame, surfaces, and substrates of the building, together with caging systems. To separate adjoining rooms, solid walls should be used between groups. These walls should be either cast-in-place with a smooth (rubbed) finish or reinforced concrete masonry units (CMU's). In either case, holes should be filled in to prevent collection of bacteria growth. In the use of CMU's, grout between blocks or tiles must be pargeted smooth to the wall surface. Epoxy or other durable finishes should be applied to the walls and floor surfaces (see below).
Ceilings must have strength, moisture resistance, and washability characteristics similar to walls. In most cases, poured concrete slabs, precast concrete planks, or skylights with protective caging are used for ceiling surfaces. When protective caging is suspended below ceiling
surfaces, lighting and other mechanical services may be mounted overhead as long as there is enough room for service access for re-lamping, etc. When positioning such protective caging, keep in mind the ability of these animals to use tools, such as sticks. Although gorillas in the wild are not tremendous tool-users, in captivity they prove fairly competent with tools. This is of greater importance if you wish to design housing flexible enough to contain other species such as chimpanzees or orangutans.

Pour-in-place concrete floor structures should be sloped to drain at 1/4" to 1/2" per foot. Drains are typically a source of individual preference or management style. While drains in the back corners allow for hosing to be done while animals are in their quarters, with proper shifting cells and transfer doors cleaning can be done while animals are out of the room. If cleaning from within the room, simple sheet drainage planes can be oriented towards troughs along the front of the cages, outside the animal space. These trenches could slope at less than 1/8" to 1/4" per foot to major drainage structures. These should have basket inserts to collect debris. By having the drains outside the animal space, daily and emergency cleaning can be done without moving the animals.

The use of special concrete coatings should be considered. Concrete is a porous material that absorbs moisture and is slow to dry. For health and safety reasons, coatings should be used to seal the concrete, make a faster surface for water to run off, and provide adequate traction while wet. There are many products that widely range in cost. There are concrete additives and surface treatments that are applied to new construction, as well as epoxy resins at various thickness applied to either new or existing structures. Even glazed tile and grout can be resurfaced to provide proper wall and floor coverings.

After choosing the construction technique, the options of color choices need to be made. When selecting color, it is important to consider the light reflectivity or absorbing characteristics, the ability to differentiate between animal fluids and surface colors, and the physiological aspects of certain colors. Considerations should be made for the animals as well as the caretakers.

A note on caulking; while no caulk can be truly gorilla-proof, its use may be required (pest control, quarantine seals, duct and other penetrations). Silicones of 100 percent are used widely due to their inert qualities; most other forms of caulking are toxic. Caulking should be recessed to make it more difficult for animals to reach.

**Barrier and transfer systems--general:** Gorilla caging systems and types should be designed to the same strengths as for other great apes. The gorilla may be less of a facile demolition contractor than an orangutan, and not as dynamic as a chimp, but their bluff charges and point loads in dominance displays will test most steel fabrications. With the added influence of confinement for long periods of time, the animal has time to analyze the facility to dismantle it.

**Caging panels/substructure:** The use of pre-fabricated, panelized mesh systems has been used extensively in night rooms, day rooms, and shift rooms, as well as in some special rooms. 5.08 cm x (2") x 5.08 cm (2") x 6.36 mm (1/4") woven and crimped wire in 3/16" channel frames are erected into tubular or angle subframes to support the cage wall. This wall-type
provides a safe interface between care-giver and gorilla, while allowing for close visual contact if needed.

Continuous openings between caging and floor and wall planes and door panels need to be restricted to acceptable limits to prevent young apes from reaching through or escaping. In areas of high keeper interface, vertical gaps should be limited to 1/2", while other gaps may be acceptable at 1 1/2"; individual requirements need to be established throughout the caging systems.

**Keeper doors:** Hinged 3' x 6' (approximately 1m x 2m) mesh panels are used for keeper access to holding rooms, with stops towards the keeper side. This system, which swings in towards animal spaces, prevents charging animals from pushing their way into keeper zones. Considerations for sloped floors and minimum gaps under doors should be evaluated. Alternative arrangements with horizontal sliding doors are also used, yet add costs due to tracking and guiding. Slam latches with multiple paddock tabs are used to provide positive latching at key locations (see section on Security). In double doors, for major service access, furnishing or re-propping requires additional up and down connection bolts. When used for regular keeper access, cremone locks have been successful.

The most common materials used for keeper doors and mesh panels are hot-dipped galvanized steel, yet alternatives with other steel alloys including stainless steel and other prefabricated systems that may be locally available should be evaluated. Due to the high level of corrosion and abuse, fiberglass or other high density polymers may become cost-effective.

**Transfer door types:** Various forms of transfer doors have been used with gorillas. Factors to consider in selecting gate movement systems include: frequency of operation, cost of construction, frequency of maintenance, back-up system requirements, and staff experience and preferences.

Door sizes for gorillas range from 80 cm (2'8") square to 100 cm (3'-4') square. The use of mechanically advantaged devices (hydraulic, pneumatic controls, etc.) have added safety and additional control to the basic door operation. All of these forms should be designed to be locked in the open or closed position.

Gates between adjacent holding areas should be located near the cage front to facilitate training the apes to use the gates. This also allows better care-giver visibility of the gates to prevent injuring an animal during cage transfer. It is important to note that the best gate systems are rendered inoperative if there is no gate training protocol. There should be two doors (at opposite locations) leading into major animal activity areas to prevent dominant animals from blocking others.

Door materials should be chosen for strength, safety, resistance to corrosion/rust, and ease of cleaning. Doors and caging tend to be targets of aggression and display, so these elements need to be secured from vibration and noise. Polypropelene sheeting has been an effective material in reducing corrosion and noise.

**Security and safety considerations:** These buildings should be situated on a secured
site, with adequate perimeter fence. It is best to have a perimeter location or other high level of
security, to separate general public and non-essential personnel from access to the service side of
these buildings. Service access areas should be limited to essential working personnel to limit
disease transmission between humans and primates as well as to contain the animals and prevent
their escape. Special tours can be arranged for outside public to view through glass while
utilizing separate air systems.

In primary and secondary animal areas, it is essential that staff have complete visibility
before entering. "Dog legs" and "blind spots" must be avoided. Some facilities use parabolic
mirrors to compensate for these problems, but it would be better to avoid designing them in the
first place. Where corridors change direction and blind spots are unavoidable, placement of an
additional mesh barrier and security door can provide an additional security zone with good
visibility into it.

Obviously, it is essential that animals not be released into any area that is already
occupied by another staff member (see discussion on Transfer doors for locking pins). The
keepers need the ability to see both sides of any transfer door from the operator position and to
clearly see that the door is locked. For fool-proof operation, it is useful to develop a color coded,
clearly labeled door and controller system that allow for quick, reliable access to critical doors.

Housekeeping and Husbandry Elements

**Furnishings:** Climbing, perching, and elevated rest areas have been traditionally made of
hard, washable surfaces such as steel or dense plastic. Wood is normally sealed to make it non-
porous. Non-washable materials such as ropes, fabrics, etc. are typically discarded when soiled
(USDA 1991); however, Izard and Pereira (in press) have found that properly maintained wood
substances have been used for up to 20 years with no indication that they harbor harmful
pathogens. Many types of sleeping platforms have been provided in interior holding facilities.
Consideration for easy access for all age/sex classes must be made. Sizes will vary, depending
on the number and type provided; however, as an example, Zoo Atlanta uses a corner sleeping
platform that is approximately 5' x 5'.

The use of items such as rope or fire hose hammocks or flexible, heavy-duty chainlink
fabrics increase the complexity and variability of the indoor habitat, providing opportunities for a
full range of activities. Access for replacement, re-propping and the development of tamper-
proof attachments will increase long-term use.

Behavioral Enrichment Areas/Devices

Built-in opportunities for the animals to change lighting levels, vary light intensity or
color and activate "basking lights," activate fans, etc., need to be organized within the electrical
and security systems. Various feeding and watering devices have been designed and proven
effective for great apes, yet their integration into the building's architecture and engineering
systems is usually lacking. This again is true for the attachment of a myriad of dead limbs,
branches, coarse fabrics, bamboo poles, ropes, artificial vines, and browse holders. These
elements need to integrated into the overall plan for construction/renovation.
Training

All training and conditioning for gorillas is currently recommended as "hands-off" management. While some notable examples of human/gorilla interaction have been reported (e.g., Howletts Zoo, the Gorilla Project), concern for keeper safety needs to be primary. The concept of "protected contact" has evolved with many success stories, including work with great apes (Desmond and Laule, 1991), involving a safe and voluntary interaction between trainer and gorilla. Through the use of special sleeves or other devices, potentially stressful events such as blood draws and urine collection can become positive encounters. Again, early planning and agreements among a collaborative design team (including keepers, trainers, education staff, and research personnel, as well as the upper level policy makers) are needed.

Bedding/Food Storage

Softening of the hard/sealed concrete enclosure can be achieved by the use of various kinds of litter. Bedding is especially important when access to exterior habitats is not permitted, due to weather or access problems (Chamove et al., 1982). Not only the choice of bedding type, but the method of delivery and replacement needs to be considered.

USDA (1991) requires that "supplies of food and bedding be stored in a manner that protects the supplies from spoiling, contamination, and vermin infestation." Storage areas should have easy access to the outside service and delivery areas yet be convenient to animal areas. Tool storage should be convenient to work areas, but well out of reach of the animals. Storage for soiled bedding, animal and food wastes, etc., must be isolated from vermin and insect pests and kept well away from clean bedding. The path by which waste products are taken from animal areas should not go through areas where clean food or bedding is transported, stored, or prepared.

Pest Control

Control of pests must be integrated into both management practices and design. From a design point of view, the following recommendations are offered:

1. "In food preparation and staff areas, provide 1.91 cm (3/4") of space between the back of shelves and counters and the wall. Some zoos prefer shelves made from wire mesh rather than solid material and avoid using doors on cabinets.

2. "In exhibit areas, provide access points into every void space inside artificial rocks and trees. Large voids require an access port large enough for occasional entry. Smaller voids should be provided with 15.24 cm (6") diameter access ports. These ports must be outside animal areas or be gorilla-proof.

3. "In animal holding areas, voids formed in the steel fabrication of the caging must be filled, sealed, or provided with access. Avoid narrow spaces between caging and walls if possible. Where necessary, these narrow spaces can be filled with caulkings, but it must be recessed out of apes' reach, even when items such as
Indoor Environmental Factors

**Natural skylights:** Recommendations concerning the use of direct skylighting is a complex issue. NIH (1972) recommends against use of exterior window and skylights due to resulting variation in temperature and light levels, even though this species lives with such variable conditions in nature. Holistic understanding of the use of sun angles, materials, and their thermal properties, together with containment barriers, etc., should encourage the use of skylights and windows without any damaging effects. Further, windows for both sunlight and views are important from an enrichment perspective.

**Lighting:** Replication of natural solutions for lighting in an indoor environment is recommended. Long-term exposure to artificial light may create implications for primates' health and reproductive cycles. The *Orangutan Husbandry Manual* suggests a two-part lighting system:

1. Light levels should vary following the natural model, bright near the top of the space, darker at the floor level.

2. Provide a separate utility light system to take care of cleaning and surveillance.

Full spectrum fluorescent lights or skylights should be used where possible. A minimum of 50 ft-candles should be provided within the cage area. Consider the reduction in light levels as the light may need to travel through glass or caging materials. These lights or skylights should be located out of reach of the gorillas (including branch wielding primates), while being accessible to the keepers for re-lamping, etc.

**Electrical:** Electricity must be provided for a range of utility equipment, refrigerators, lighting, and heating/ventilation systems. Clear placement of panel boxes is needed, designed for expansion and simple replacement. Access to dedicated circuits for separated electrical uses needs to be provided in a thoughtful and safe plan. Outlets must be ground fault interrupter type with waterproof housings mounted at least 1.3m above the ground.

The need for a back-up generator during emergency use should be considered, depending on climatic region and the likelihood of power failure. Considerations over which electrical needs are necessary for inclusion on emergency panels should be analyzed; typically, lighting/heating/circulation systems, door controls, hotwire, and emergency procedure equipment outlets should be addressed.

Locate all electrical equipment (lighting, contactors, switches, etc.) completely out of animal access. Locate electric panels where they are accessible to service personnel without entering animal zones. To give the animals more opportunities to control their environment, safe/motion sensitive switches may be considered as part of an overall behavioral plan and integrated into electrical systems.

**Plumbing:** Drinking water must conform to human quality standards. Pre-treatment and
filtration systems on an institutional level should follow into each animal zone, interior and exterior. Multiple locations should be provided to allow access by multiple individuals. "Lixits" are an effective and simple watering device for great apes. They have pressure regulators built-in to each nozzle. These should be linked together in a domestic water line system. Multiple locations at opposite side of the rooms should be planned to ensure free access for lower ranking group members. Keep piping and nozzle out of animal reach.

No standard pipe or drain size is recommended in this manual. Plumbing systems sized to the drainage areas and characteristics are recommended. USDA (1991) required code elements must be integrated into a complete system. Industrial materials and local design standards should be followed in strict compliance and practice. Outdoor water sources should be "heat traced" in cold climates as needed. Access **must** be provided to tracing for continual maintenance.

The facility-wide service system, including pumps, heaters, drainage, etc., ideally should be well-planned, integrated, and standardized. A standard kit of parts should be kept at each location to allow for ease of replacement and maintenance without time loss or emergency actions.

**Ventilation:** High levels of air circulation are desirable due to control of airborne bacteria/parasites, odor, and dampness. NIH regulations requiring 10-15 air-changes per hour tend to be set for laboratory conditions; these regulations are based on small areas with high concentrations of animals or even areas of potential "contamination," such as medical lab space or waste product holding, rather than zoological facilities. More appropriate standards for zoos might be based on cubic area rather than square footage, along with definitions for filter and maintenance requirements.

"Air entering any animal rooms should be fresh air and should be exhausted without recirculating (100 percent air exchange in animal rooms) or equivalent if possible. It is unrealistic (and very energy inefficient) to void high quantities of conditioned air in large day rooms or where there is a very large volume of air per animal provided in the space enclosed. Ventilation requirements for such areas should be determined individually on a performance basis. Besch (1980) suggests that ventilation requirements should be based upon the rate per animal. Woods et al. (1975) agree with this approach and found it an energy efficient means to provide an odor free environment. It is often wise to design a multi-stage ventilation system which can be run at "low" or "high" settings depending upon the animal occupancy levels of the areas at a given time." (Coe, 1994)

Subdivided air circulation zones are recommended to allow for variation in different use areas, as well as separation between housing for similar species of great ape or primates to prevent cross-contamination.

Interior control of heating and ventilation systems require automated, thermostatically controlled devices, measuring temperature inside the animals' air system. Locate all mechanical and plumbing equipment (ductwork, hose bibs), completely out of animal access; including insulating material over ductwork.
**Temperature:** Recommended ranges for tropical primates in captivity are dependent on individual medical needs, but can be generalized:

- **Indoor minimum:** 65 degrees F. (60 degrees F. with heat lamps) [18 degrees C]
- **Indoor maximum:** 85 degrees F. [30 degrees C]
- **Outdoor minimum:** 45 degrees F. if overcast/rain [7 degrees C]
  
  30 to 35 degrees F. if sunny [-1 to 3 degrees C]

Animals should be given access to indoor holding if it is cold and wet; it is recommended that they not be allowed out if temperatures are below 35 degrees F (3 degrees C). Wind speed and wind chill needs to be taken into account in evaluating outdoor conditions.

**Humidity:** The range of indoor humidity normally recommended is 30 percent to 70 percent; however, these animals clearly come from areas of higher humidity. Managers must look at a balance of temperature, humidity, and ventilation to arrive at a reasonable comfort level for gorillas and keepers.

In either indoor or outdoor environments, fog, misters, and even rain effects can be employed to provide daily variation. Used carefully, such techniques may assist with irrigation as well.

**Fire Safety**

Primate buildings should be built to retard smoke or fire damage. Non-combustible materials should be used in construction and an appropriate and adequate life safety system installed. This could include smoke and heat detectors, sprinklers, fire dampers, and emergency ventilation systems. It is important to note that smoke inhalation can be just as dangerous as actual flames. Zoo-wide fire alarm systems need to be integrated into a fire safety plan. Ready access to fire extinguishers is important. Detectors should be set to go off in the building, as well as in a continually staffed area, such as the zoo security office.

Coordination with local fire officials and security personnel is necessary to develop standard operating procedures in case of a fire. Primate buildings should have good fire truck access, water supply, and fire hydrant access. Action plans and contingencies for other emergencies should also be prepared and rehearsed. Special life safety experts should be used to advise designers on developing the best system and management strategy for each project. Fire insurers should also be consulted for their expertise.

**Sensory Environment**

The effects of noise on captive animals remain little understood. As with humans, there is basic understanding that loud noise is stressful (e.g., Tempest, 1985, de Boer et al., 1988, 1989). However, the effect of noises that are moderately loud are less clear. In humans, moderately loud noises are generally found to be "annoying," or "irritating," and may negatively affect performance (e.g., Tempest, 1985). In non-human animals the effects of moderately loud noises range from possibly negative effects (gorillas: Gold and Ogden, 1991; giant pandas: Czekala,
Indoor environments for captive animals are filled with a variety of sounds. With gorillas, preliminary data suggest that the presence of some of these sounds (e.g., food preparation, cleaning, and other species' vocalizations) may be stressful to gorillas in indoor environments (Ogden et al., 1994). This is clearly a factor when designing exhibits and may recommend the use of more sophisticated acoustical treatments than are generally included in holding areas. One method often used in human environments is a "masking" treatment: the use of another sound or music to essentially cover up potentially stressful or annoying sounds. Unfortunately, the use of such a treatment in the previously mentioned study was only marginally successful. Previously recorded natural sounds were introduced to indoor holding area; while the stressful effects of sounds such as cleaning were eliminated in younger animals, the stressful effects were actually increased in adult animals.

Mechanical equipment required to move large volumes of air can be a major source of indoor noise pollution, and appropriate noise dampening techniques should be incorporated into the design of building mechanical systems. Most noise absorbent materials are not waterproof, but there are a few opportunities, such as the use of deep bedding and natural plant materials, that can be used to quiet the environment.

**Interior Planting**

Although the stress and abuse given to the interior habitat is extensive, methods have been employed to introduce living plant materials within the interior zone. The added qualities that plants provide to interior air should not be overlooked. Many facilities have included provisions (drainage, light weight soil, skylighting, and irrigation systems) for planting pockets and troughs out of reach of the animals behind mesh, yet within their space. Early examples at the Houston Zoo, Lincoln Park, and Basel Zoo have given foreground and/or background locations for interior tropical plants and vines. At the Dallas Zoo, interior day rooms have built-in planters outside the mesh line to wrap the gorillas within a green curtain. Unfortunately, maintenance, irrigation, and lighting are inadequate, and success has not been achieved (see Figure 10). The use of "green walls" has been successfully used in experimental applications in tropical pavilions in Denver, Seattle, and Zurich. These planter boxes can be mounted above barrier heights with internal irrigation and drainage.

**DESIGN CHECKLISTS AND SURVEY RESULTS**

As a summary of the above data, we have outlined a checklist of "Design Recommendations" for consideration in the design or renovation of a gorilla facility. Obviously, each institution has to determine the goals for the collection and the priority it has within the context of other programs. We tried to establish some of the criteria to be reviewed and questions to ask in the design process.
GENERAL DESIGN PROCESS CHECKLIST

1. Establish a multi-disciplinary design team including representatives from a wide range of zoo staff representatives, as well as experienced consultants.

2. Build three-dimensional models of proposed facilities to allow staff to simulate daily routines and emergency procedures.

3. Look beyond minimum standards towards facilities that will not soon become obsolete and that may provide flexible housing for other species; provide for a wide range of species-typical behaviors.

OUTDOOR HABITAT CHECKLIST

1. Encourage the design of multi-group habitats to enable long-term management of family groups.

2. Maintain minimum, agreed-upon dimensions completely around the animal area perimeter, utilizing a variety of barrier types to allow for visual relief and wide range of views.

3. When possible, design facilities that are flexible enough to house other great ape species.

4. Create a rich, manipulative, complex naturalistic environment with a variety of furnishings and substrates to encourage animals to control their environment and exhibit species-appropriate behaviors: natural deadfalls, plant materials, rocks, sand areas, streams, waterfalls, and topographic features.

5. Establish hardy, edible/nontoxic plantings in rotational islands to allow for foraging behaviors as well as fallow zones.

6. Use locally hardy/vigorous plant materials with characteristics that are found in plant materials of the rain forest habitats; i.e. driptips, large glossy leaves, ferns, red new growth.

7. Analyze sightlines at visitor viewpoints to restrict distracting views and experiences.

8. Provide opportunities for rotation between exhibits and interaction between gorilla groups and cross-species interaction, including introduction/migration doors between habitats and display points for intergroup communications.

9. Improve visitor viewing by encouraging gorillas to use key viewing areas by carefully siting features such as micro climatic areas (sunny/shady), flat
resting/leaning areas, and forage areas/feeding devices.

10. Provide the visitor with aesthetic encounters with the simulated natural world to improve the visitor's appreciation of the animals and their landscape.

11. Consider mixed-species opportunities to encourage cross-species interaction and improved visitor education.

12. Provide interpretation for visitors on the complexity of rain forest habitats, including associated exhibits that interpret the "web of life" and biodiversity messages.

13. Establish a variety of viewing opportunities at a wide range of levels (elevations) that are behaviorally respectful to the gorillas and provide adequate flight distance from public or caregivers. Consider all public users in the design of viewing areas, including strollers and wheelchairs, while maintaining safe barriers.

14. Provide non-invasive viewing opportunities with the use of viewing blinds, one-way glass, video camera surveillance, and heavily screened landscaped viewing areas.

15. Design observation areas into exhibits, for keepers and researchers.

16. Because the area near the holding facility is often a preferred resting area, either make that area less comfortable to the animals (e.g., more steeply sloped) or make it attractive and visible to the visitors while screening views of the building itself.

17. Provide and maintain service access into the major habitat areas for landscape and furnishing replacement, including crane erection.

INDOOR HABITAT CHECKLIST

1. Design appropriately sized, climate-controlled, interior support facilities to provide shelter for gorillas and caregiver service areas.

2. In cold climates, provide large dayrooms in addition to outdoor environments, with natural skylighting and/or windows, climbing structures, and natural materials to promote species-appropriate behaviors. These rooms are not a substitute for outdoor habitats but a compliment to a whole life-care facility.

3. Consider designing "environmental rooms" with soft substrate zones, planting areas, water features, and climatic diversity (rain, wind, full spectrum lighting, basking areas, etc.).

4. Maintain secure/safe access for service personnel and convenient access for replacement of natural materials and other construction access.
5. Provide for a variety of training and husbandry opportunities within the indoor habitat that allow for a wide range of protected contact encounters.

6. Provide aesthetic encounters with natural landscaping to increase the visitor's appreciation of the animals.

7. Consider mixed-species opportunities in the programming of the habitat to encourage species-typical behaviors and improved visitor education.

8. Provide off-exhibit holding areas that are secure and cleanable environments, designed for rotational flexibility with shifting capability.

9. Build in vermin control features.

10. Utilize basic mechanical systems based on industrial engineering practices for life support, plumbing, electrical, and ventilation systems. There is a movement toward complex computer-managed, highly integrated systems. Such systems have key advantages; however, they are also expensive and require more intensive management.

11. Consider the use of transfer door control systems with hydraulic, pneumatic, or electric operators.

12. Provide climate control, moisture control, and ventilation systems that match the needs of the animals with the given climate. Optimize the animals' acoustic environment.

13. Provide daylight, fresh air intake, and exhaust for the interior habitat.

14. Provide high quality potable water systems in every room that an animal is expected to occupy; provide additional locations in rooms where these water outlets can be used.

15. Consider behavioral enrichment devices and training opportunities designed into holding areas and keeper routines. Consider creative ways to give the animals more control over their indoor and outdoor environments.


17. Provide for fire safety controls and smoke dampening in the design of interior habitats; coordinate emergency procedures with local fire fighters.

18. Coordinate building mechanical, electrical, plumbing, caging, and animal movement systems carefully.

19. Simple and or duplicate systems should be planned in the overall utility system for the facility.
20. Design special rooms and suites that are appropriate to the level of management and care provided within your facility, including introduction suites, quarantine suites, and hand-rearing suites within visual contact of family members. Consider the needs for squeeze/metabolic/collection cages, weigh stations, and overhead shift and transfer cages and if they should be portable or de-mountable systems.


SURVEY RESULTS

The Gorilla Husbandry Survey contained 34 major questions related to design issues. We present relevant data from the survey in order to focus on baseline "State-of-the-Zoo" design parameters. Remember that these data represent past design parameters in exhibitry and holding facilities. A number of projects presently in design exceed these measures, showing that design standards for great ape facilities continue to evolve. As Coe and LaRue have stated (in press), "it is the designer's responsibility to exceed the standards rather than to simply meet them."

Types of Exhibit

From the respondents, their outdoor habitats for gorillas are between 1 and approximately 50 years old (see Figure 11). Designs evolved from early sterile-caged quarters to more enriched, open-air enclosures. Seventy-seven percent of the facilities responding to the survey reported
having at least one outdoor (open air) public viewing exhibit for gorillas. Approximately 50 percent had indoor (climate controlled) public viewing exhibits, 82 percent had indoor holding without public viewing, 10 percent had indoor holding with public viewing, and 16 percent had off-exhibit (no public view) open-air, play yards. Number of facilities, by these survey types, are presented in Table 1.

Efforts to continue building and renovating gorilla exhibits is staggering. Each facility is under constant scrutiny, adjusting and modifying its habitats for primates. At the core of these efforts is improved (but still limited) knowledge regarding what provides well-being for animals. Of the 39 gorilla facilities surveyed (all built since 1950), 76 percent either have renovated some part of their facility or plan to in the future. The surveyed institutions responded with: 41 percent (16) have renovated in the past ten years; 35 percent (14) plan to renovate; 26 percent (10) plan to renovate in the next four years.

Table 1. Number of facilities, by type.

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Outside Public</th>
<th>Inside Public</th>
<th>Off-exhibit holding</th>
<th>On-exhibit holding</th>
<th>Off-exhibit outside play yard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td>10%</td>
<td>16</td>
<td>41%</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>49%</td>
<td>12</td>
<td>31%</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>23%</td>
<td>5</td>
<td>13%</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>5%</td>
<td>2</td>
<td>5%</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3%</td>
<td>5</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>3</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>2</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>0</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>1</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>1</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>1</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>5</td>
<td>13%</td>
<td>3</td>
<td>8%</td>
<td>5</td>
</tr>
</tbody>
</table>
Types of Special Facilities

The results included data about types of special facilities that are associated with these gorilla exhibits. Questions were asked concerning the level of husbandry practiced in these facilities and what level of medical operations and research opportunities were used.

Behavioral research has become an integral part of gorilla management in many institutions; 81 percent reported having a research observation area for the facility, with 43 percent in the outdoor exhibits.

Management of gorillas to allow the opportunity for introductions has been designed into the overall facility, with 82 percent of the indoor holding areas, 12 percent of the outdoor habitats, and 25 percent of the indoor habitats reporting socialization/howdy doors. Special facilities results are presented in Table 2.

Table 2. Percentage of institutions with specialized features, broken out by whether feature is present in inside area, outside area, holding area, other, and total.

<table>
<thead>
<tr>
<th>Type of Special Feature</th>
<th>Feature in inside area</th>
<th>Feature in outside area</th>
<th>Feature in holding area</th>
<th>Feature in other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-rearing facility</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>Isolation facility</td>
<td>7</td>
<td>0</td>
<td>33</td>
<td>17</td>
<td>57</td>
</tr>
<tr>
<td>Medical treatment room</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>46</td>
<td>58</td>
</tr>
<tr>
<td>Nursery facility</td>
<td>5</td>
<td>0</td>
<td>7</td>
<td>33</td>
<td>45</td>
</tr>
<tr>
<td>Quarantine facility</td>
<td>3</td>
<td>0</td>
<td>17</td>
<td>38</td>
<td>58</td>
</tr>
<tr>
<td>Research/observation area</td>
<td>15</td>
<td>43</td>
<td>20</td>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td>Restraint/squeeze device</td>
<td>2</td>
<td>2</td>
<td>17</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Socialization/howdy doors</td>
<td>25</td>
<td>12</td>
<td>82</td>
<td>2</td>
<td>121</td>
</tr>
<tr>
<td>Urine collection trough</td>
<td>2</td>
<td>2</td>
<td>30</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Weigh station</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>

Design Features

The survey included information on features relevant to the actual design of the facility. These included not only basic sizes and numbers, but design features such as: types of containment; enticements to draw gorillas closer to public; water features; exhibit size, viewing levels and outdoor materials; exhibit access; shift and holding facilities; interpretive graphics.
The above design features are discussed.

**Containment**

Exhibit design has gone far beyond simple containment issues. The biggest challenges in development of natural habitats is to minimize visible architectural elements and diminish the separation between visitor and animal. To this end, 18 of 39 facilities (46 percent) reported using artificial rock as a primary containment barrier; no facility reported incorporation of "ambient" rock as a barrier. The minimum wall height reported was 3.65m (12 feet) at 6 facilities, the maximum wall height reported was 6m (20 feet) at 2 facilities, with an average of 4.34 meters (14.2 feet).

Wet moats were used as primary containment at 9 (23 percent) of the 39 facilities. These depths ranged from a shallow 0.3m (12 inches) to a depth of 6m (20 feet). Wet moat width also varied from a minimum of 3.1m (10 feet) to a maximum of 14.6m (48 feet). Dry moats were used at 13 (33 percent) facilities, with depth ranging from a minimum of 3.6m (12 feet) to maximum of 6m (20 feet). Dry moat width also varied from a minimum of 3.1m (10 feet) to a maximum of 5.4m (18 feet). Results are shown in Table 3.

<table>
<thead>
<tr>
<th>Barrier Type</th>
<th>Number of Facilities</th>
<th>Range (in meters)</th>
<th>Average (in meters)</th>
<th>Range (in feet)</th>
<th>Average (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry moat: Depth</td>
<td>13</td>
<td>3.6 - 6.0 m</td>
<td>4.5 m</td>
<td>12 - 20 ft</td>
<td>15 ft</td>
</tr>
<tr>
<td>Dry moat: Width</td>
<td>13</td>
<td>3.1 - 5.4 m</td>
<td>3.9 m</td>
<td>10 - 18 ft</td>
<td>13 ft</td>
</tr>
<tr>
<td>Vertical Wall: Height</td>
<td>15</td>
<td>3.6 - 6.0 m</td>
<td>4.3 m</td>
<td>12 - 20 ft</td>
<td>14.2 ft</td>
</tr>
<tr>
<td>Wet Moat: Depth</td>
<td>9</td>
<td>0.3 - 6.0 m</td>
<td>3.2 m</td>
<td>1 - 20 ft</td>
<td>10.5 ft</td>
</tr>
<tr>
<td>Wet Moat: Width</td>
<td>6*</td>
<td>3.1 - 14.6 m</td>
<td>5.6 m</td>
<td>10 - 48 ft</td>
<td>18.6 ft</td>
</tr>
</tbody>
</table>

* missing data

Glass was used as a barrier at 19 (49 percent) of 39 respondents' facilities, while steel bars were reported at only one (2.6 percent) facility, woven wire mesh at four (10.2 percent) institutions, and welded wire mesh at six (15.4 percent). Mesh size ranged from a minimum 2 inches by 2 inches to a maximum of 4 inches by 4 inches.

**Enticements to Draw Gorillas Closer to Public**

Various features were incorporated into outdoor habitats to encourage the gorillas to spend at least some of their time in closer proximity to visitor viewing areas. This was accomplished by providing the following attractive features at those areas. Food was used as an
enticement in 13 reporting facilities. While this may seem to fall into an animal management/husbandry strategy, providing in the initial design access for food and for loading and cleaning food devices, is helpful for future staff maintenance of the exhibit. Warmer and cooler surroundings were accomplished through radiant heaters (5 facilities), "hot rocks" (5 facilities), "cool rocks" (3 facilities), and shade/overhang area (15 facilities). Water sources were used as enticements at 9 facilities, although it is not clear from the survey what the application was.

Water Features

Almost all (87 percent, 34 or 39 zoos) of the zoos surveyed reported having a water feature and allowing the gorillas access to it in their outdoor habitat. The most commonly used water feature was a waterfall, with 22 of 39 facilities featuring at least one in the outdoor habitat. Streams were reported in 21 of 39 (54 percent) facilities, and water moats were reported in 11 of 39 (28 percent) facilities.

Exhibit Size, Viewing Levels, and Outdoor Materials

Exhibit sizes varied greatly, ranging from the smallest at 58 sq. m. (625 sq. ft.) to the largest at 10,450 sq. m. (112,500 sq. ft.). Sixteen of the 32 exhibits for which data were available are at least 90 sq. m. (1,000 sq. ft.).

Viewing levels for primate exhibits have been the subject of discussion for many years (Coe, 1985). Over one-fourth of the responding zoos had multi-level viewing experiences. Most facilities (72 percent) had visitor viewing at the same level as the gorillas (28 of 39), fewer, 41 percent (16 of 39), had viewing above the gorillas, and only six (15 percent) facilities had viewing below the gorillas.

Natural earth/grass substrate was available to the gorillas in 36 of 39 (92 percent) responses. Gunite was used in 13 (33 percent) institutions, concrete was used in 9 (23 percent) facilities.

Exhibit Access

The amount of time the gorillas had access to exhibits varied greatly and was undoubtedly weather-dependent and seasonal in most regions. According to respondents, the time gorillas spent in their outdoor habitat ranged from 3 hours daily to 24 hours daily. The number of months per year that the gorillas were given access to outdoors ranged from 4 to 12 months, with 24 of 39 (62 percent) institutions reporting outdoor access year round. Access for vehicles and equipment was available at 12 of 39 (31 percent) facilities.

Shift and Holding Facilities

A tunnel or hallway was used to shift gorillas between indoor and outdoor exhibit areas at 20 of 39 (51 percent) institutions. Gorillas could be shifted directly from the inside exhibit to
the outside exhibit at 18 institutions. Access from inside to outside was on the same level in 13 facilities, whereas gorillas were required to go up in one facility, and to go down in two.

A variety of door systems were used to shift gorillas from indoor areas to outdoor exhibits. Electric doors were used at 5 facilities, manual doors used at 20 facilities, pneumatic doors used at 2 facilities, and hydraulic doors used in 9. Guillotine doors were used at 17 facilities, side slide were used at 18 facilities. In the event of mechanical or electrical failure, 14 facilities reported having an emergency override system in place in order to operate doors.

Doors were constructed of a variety of materials; steel mesh is used at 8 facilities, steel bars are used at 7 facilities, lexan panels are used in 11 facilities and are removable at 1 facility, and glass panels are used at 1 institution. Solid panels are used at 25 of 39 facilities responding; they are removable at 3 facilities.

Interpretive Graphics

Of those zoos responding to these questions on the husbandry survey, 72 percent have flat graphics at their gorilla exhibit (18/25), while only 12 percent (3/25) use interactive graphics. Sixteen percent (4/25) use video while only one institution uses auditory immersion. Almost 90 percent (22/25) utilize staff or volunteers to interpret exhibits for the guests.

ACKNOWLEDGEMENTS

We would like to thank the authors of the design chapters in the *Chimpanzee Husbandry Manual* (Randy Fulk and Chris Garland) and the *Orangutan Husbandry Manual* (Jon Coe and Mike LaRue) for their guidance in establishing elements of the format used in presenting this work as well as some of the actual guidelines, and Debra Forthman for a review of an earlier version of this manuscript.
Ad libitum notes and day-to-day impressions about the animals under our care are valid and vital to the sound management of those animals. Unfortunately, these type of data are the most difficult for other institutions to use and to learn from. Further, strong interpretation of such notes can lead to mistaken impressions of animal behavior. It is the intent of this section to assist animal caretakers and managers not only to systematically study and learn about their individual animals, but to do so in such a manner that they produce information that is helpful, reliable, and widely applicable to other institutions. We hope this information helps the reader to learn about and move towards optimal management of Gorilla gorilla gorilla.

The area of behavioral research can be difficult and confusing. This is particularly true in a zoo setting, where the sample sizes are often small, exhibits do not always meet the animals' needs, and there are myriad confounding variables. In order to conduct a study with meaningful results that can be applied to individuals outside of your institution, there are a number of decisions to make and factors to consider. It was our intention to assist in those decisions by recommending and describing specific data collection protocols, detailing procedures, pointing out the strengths and weaknesses of these protocols, describing equipment and apparatus, and providing some sample data sheets.

We will be focusing on two types of data collection protocols. These protocols can be used to answer a wide array of research questions. They were chosen for the ease of data collection, the speed of data acquisition, the minimal amount of time required for each data set, the number of observers that can be brought into acceptable agreement--both internally (between observations) and externally (between observers)--ease of interpretation, and the manner in which the methods complement one another. The following document briefly describes both of the recommended data sampling and recording techniques, outlines their pros and cons, and offers methodological advice for each. If neither technique is satisfactory, there are several good articles and books that outline other techniques (see recommended reading list).
behavior was observed. The uses of this particular type of data collection are:

1. To assess the manner in which animals are using their space: how they partition space between one another, temporal patterns of use, utilization (or underutilization) of exhibit features and areas.

2. To evaluate the social situation by determining proximities, looking at access to preferred locations, or determining which animals are most frequently associating or not associating, etc.

3. To determine the proportion of time animals spend in various behavioral states (proportion of samples where the animals are active, sleeping, foraging, etc.).

4. To note gross developmental (ontogenetic) changes in behavior.

The weak points of this particular type of data collection technique are:

1. Rare or very short behaviors will be underestimated.

2. Observers generally have a bias towards recording conspicuous or notable behavior that happened just prior to or after a sample was supposed to be taken.

3. It is easy to get confused and think that the numbers represent true frequencies rather than the frequency of observations in which the behavior was observed.

BEHAVIOR SAMPLING USING A CONTINUOUS RECORDING TECHNIQUE

Another technique that addresses some of the problems mentioned above, but that has its own weaknesses, is behavior sampling using a modified continuous recording technique. In this method, the observer watches an entire group, select subgroup, or individuals in succession, for a preestablished period of time, and records each time a particular preselected and carefully defined behavior or set of behaviors occurs. This data collection technique generates true frequencies. With this technique, one can examine the following types of questions:

1. Rates, levels, and forms of agonistic, reproductive, or specific parental behavior patterns.

2. Specific responses to environment devices (i.e. enrichment), although you probably can determine behavioral responses to more general environmental modifications using the first data collection technique described.

3. How groups or individuals are spending their time.

4. Interaction sequences.
The weak points of this particular type of data collection technique are:

1. Again, there is the tendency to record the most conspicuous behaviors. It is very important that the behaviors to be recorded are carefully selected, clearly defined, and mutually agreed upon by all of the observers.

2. With this technique, the longer a bout of behavior lasts, the more likely it is that the behavior will be underestimated. Avoid long-duration behaviors like resting, foraging, eating, etc.

3. You must carefully define what constitutes the beginning and end of a behavior.

4. As with the first technique, you still cannot make statements about how much time an animal spends in various activities. You still are not collecting data on behavioral durations. This weakness can be resolved if you record the actual duration of select behaviors (that is, you can note the start and end times of the behavior). Keep in mind that with each new task it will be more and more difficult to obtain concerns between observers.

USING BOTH TECHNIQUES

There is a lot to be said for using both techniques together. An observer might, for example, begin and end a behavioral sampling session with scan sampling. In this way, the strengths of both methods can be utilized. Unfortunately, the data are not equivalent and cannot be combined.

METHODOLOGY NOTES

Reducing error in the data: There are two approaches to minimizing error in the data, and, if you are collecting data in a zoo situation, there is potential for plenty of error. One way is to account for as many extraneous variables as possible by being as consistent as possible. Do everything in the same order, in the same way, at the same time. The other way is to randomize the who, where, and when of data collection as much as possible. This approach guarantees that systematic error will be minimized or at least spread evenly throughout data. You will be better able to generalize your data across situations, time-of-day, groups, etc. if you choose to randomize.

What to observe: Regardless of the technique, it is very important that the number of discrete behaviors or behavioral categories being monitored be kept to an absolute minimum. It is difficult to say exactly how many behaviors can be reliably observed. This depends greatly on the behaviors selected and the experience of the observers. As a rule of thumb, it is probably unwise to attempt data collection on more than 15 discrete behaviors. Careful perusal of various ethograms (the "Compilation of Gorilla Ethograms" by the Gorilla Behavior Advisory Group of
the SSP, 1990, can be a resource), along with thoughtful phrasing of the research question will help narrow the scope and dictate the level of detail selected for study. We advise using one or more of the published ethograms as a guide and then as a menu from which to select the behavior(s) of study.

**Who to observe:** A well-considered and carefully worded research question will determine who you observe. It takes just a little more thought to determine the order in which you observe the animals. It seems logical that if your question involves reproductive behavior, you include only reproductive animals in your study. Just as questions about the impact of hand-rearing require locating and observing hand-reared animals. If you are studying an entire group or subgroup, the order in which you observe them is an issue. It is usually best to randomize this, which can be as easy as selecting names from a hat. Just be sure that all the animals are observed an equal number of times. Try to accomplish this over short periods of time (e.g., every 5, 7, 10, or 14 days, "Atilla" is observed 8 times). You certainly don't want to be collecting 87 data sets on "Atilla" during the last week of the study to make up for lost or uncollected data.

**When to observe:** Making observations on a set or predetermined schedule and for a predetermined period of time is a good way to guard against observer bias. The times of observation and the duration of each observation period is greatly determined by joint consideration of the question being studied and the realities of the work situation.

As practical advice, if your question is not really or should not be time-of-day dependent (i.e., how do the animals partition and then use the exhibit, or what are the activity budgets of this group of animals), randomly select the time of observation just as you might randomly select the animal you are going to observe first. Make sure that over a predetermined period of time (again, 5 days, 10 days, two weeks, etc.), all times of day are equally represented. If your question is time-of-day dependent (e.g. "Jezibell" only has access to the exhibit three hours a day, or you are interested in play behavior that most frequently occurs in the morning), randomly select time slots within the times of most interest. If you cannot guarantee observations at random times, then collect data at the same time every day. This is acceptable, but remember--you cannot generalize your findings to other times of day. All of the observation times should be scheduled in advance. This is one of the best favors you can do for yourself, because observers can adjust the schedule if data are missed or there is an unexpected problem, others can inform you if a problem arises, and interference from others can be minimized.

**How to observe:** The goal of most observational research is to let the subjects do what they do (sometimes in the face of systematic manipulations) while an observer unobtrusively documents the behavior. After just a few observations, it will become clear that the gorillas know they are being watched, even when observed from a public area. In some cases, their response is dramatic--protective clothing or handiwipes can be helpful. It often takes quite a long time for the animals to get used to an observer's comings and goings. This problem is exaggerated if the observer is a keeper. It takes the animals some time to realize that within the "observational context" (clipboard, stopwatch, and pencil in hand), procedures, cleaning, feeding, or other management activities are not forthcoming. It is a good idea to allow some time at the beginning of a project, and even at the beginning of a data set, for the animals to get used to or become aware of the observers. It is our experience that hiding is futile. It only leads to a great deal of frustration, anticipation, and confusion.
It also helps to exercise your best great ape manners. Turning sideways to the animal in order to minimize your profile, not staring, no sudden moves, and keeping noise to a minimum are all advisable. Do not chat with the animals during a data set or call them by name. Whatever you do, do not feed an animal just before, during, or after you collect data.

**Who observes:** You need to be sure that everyone collecting data is in agreement on the who, when, and how of data collection for reliability. If there is only one observer, this person must be sure that there is reliability between data sets, particularly if data are collected over a long period of time. With increasing skill and the passing of time, mutation of behavioral definitions is inevitable. Repeat reliability testing should be performed as well. Reliability checking can be very complex—remember that a high degree of agreement (85 to 90 percent) needs to be maintained between observers. With the two data collection techniques described here, accuracy in identifying behavior, in correctly coding behavior, and in using the data sheet need to be checked. It is sometimes helpful to have videotapes that are already scored available for reliability testing, although using the real thing (the animals) is usually better and easier for the observers. Unfortunately, you cannot always guarantee that the animals will be active when you want to check someone's reliability, and passing someone on a reliability test for accurately recording that an animal is asleep is not acceptable. You will need a relatively active and behaviorally diverse data set. It is here that prerecorded videotapes of behavior can be helpful.

**SUPPLIES**

The supplies required for behavioral observations can be very simple. They can also be quite expensive. The following is a list of recommended equipment, preferably the cheap-yet-effective kind.

**Essential:**

Stopwatch—any stopwatch will do. It is helpful if it is digital, has a large easily read display, and a string to hang from your neck.

Clipboard—any clipboard will do. It is nice if it fits the size of the data sheet, legal size for legal-sized paper, letter size for letter-sized paper.

Pens and pencils—use the pens or pencils of your choice. Just be sure to take more than one with you.

**Nice to haves:**

Velcro—it is nice to be able to velcro the stopwatch to the front of the clipboard. This way you can fill out the forms, keep track of the time, and easily move about.

Recirculating stopwatch—many stopwatches can be set to emit an audible tone after a set interval. It is very handy to have a stopwatch tell you when the next data set is to begin.

Cheat sheet—it helps to have a list of behavioral codes, a location map, or even a set of rules for filling out a data sheet affixed to the clipboard.
Clear contact paper works well for adhering paper to the clipboard.

Waterproof pens--in the wet, damp, or rain, it is very difficult to write with a pencil (it gouges holes in the paper) or a conventional pen (ink melts over the page). There are some good quality but inexpensive waterproof pens on the market.

Great extras: Data loggers--there are a variety of handheld data loggers on the market. They reduce your total effort because you can collect your data directly on to a computer, and the small math coprocessor will do the basic math for you. There are some systems that were not specifically designed to be data loggers, but with some persistence they can be adapted. The negative aspects to these are: they are generally costly, and if the computer goes down you are back to the old pencil and paper.

Video cameras--they work. You will be able to record the animals' behavior frame by frame if need be. In some cases, this may be necessary. Initially video cameras seem to be "the answer," but unfortunately it usually takes two to three times longer to take data from a video than to collect it by hand. Video adds just one more step (collecting the data from the tape) before the analysis phase. Also, with video it is very difficult to ascertain the social context. The camera can only focus narrowly, and a lot of things can happen outside the angle of the lens. It makes interpretation of the data virtually impossible within the social situation. Finally, depth tends to disappear. This doesn't seem to be much of a problem until you are trying to determine where the animal is or just how far one animal is from another. Video can be a very useful for developing tapes against which you can measure reliability, however.

**SAMPLE PROTOCOLS**

**SCAN SAMPLING PROTOCOL**

This sample protocol is based on a research question where both location and some behaviors are important. The specific question is up to you.

*Time per data set:* You will need to allot about 15 to 20 minutes to complete a scan. Arrive about five minutes before you plan to record data on the first animal or troop of animals. The animals can be scanned as frequently as once every 15 minutes or as infrequently as once or twice a day, depending on your research question. It is probably safest to scan no more frequently than once or twice an hour.

*Before a scan:* Check for any messages or notes that might indicate a change in the status of a gorilla troop or individual. Then walk around the habitat looking for the animals. It
helps to locate as many individuals as possible prior to the scan. It also helps to fill out the top of
the scan sheet prior to starting your scans.

**Scans:** When it is time to do a scan, locate each individual as quickly as possible and
note what the animal is doing the instant you spotted it. Score any animal that you do not see
within five minutes of starting as NV (not visible). You have several choices about how to scan.
Whatever you decide, you will need to scan or search in a systematic way. One way is to begin
your search pattern in the same location at all times and search the exhibit in a consistent
manner. This is the least preferred technique, because you will probably consistently find the
same animals and not others. You may, therefore, introduce a consistent error into your data.
Another way is to randomly select the animal you will begin your search with, locate that
animal, and then search the exhibit in a consistent manner for the others. A third possibility is to
randomly select the area that you will start searching from and then search consistently from
there.

Regardless of the technique, searching will initially take a great deal of time, especially if
the animals are not very social and your exhibit area is large or diverse. Scanning will become
easier and faster as the observers learn where and when the animals spend most of their time. Be
careful, your search needs to remain consistent.

**After the scan series:** Check your data sheets to be sure that everything is filled in
correctly. Then take it to a common or agreed upon drop-off place.

**Completing the Scan Sheet**

Exhibit: Indicate which exhibits, habitats, enclosures, cages, etc. are available to the
animals.

Observer: That's you.

Temperature: Record the temperature.

Date: Indicate the date of the observation.

Locked out: Indicate whether the gorillas are locked out on exhibit or have free choice.

Visitors: Circle the rank that best describes the number of visitors that are around the
gorilla habitat. The range is from 0 to 3 (near riot). Most busy weekends are about
a 2.

Time: This is the time that you actually take the scan sample.

ID: Record the individuals in the order that you see them.

Enclosure #: Record the habitat, enclosure, etc. in which you find the animals. This will be
obvious if there is only one area available, but you never know.

Loc: Record as precisely as possible where in the exhibit the animal is located.

Beh: Record the behavior(s) that the gorilla is engaged in the instant that you spotted it.

Obj: If any of the behaviors involve an object, record the object. If there are several
behaviors and objects involved, specify which goes with which. For example, a
gorilla may Rest upright, Hold an object, and eat a Yam.

IP/NN: If a gorilla is interacting with another gorilla, indicate the Interactive Partner(s). If a
gorilla is near another gorilla (within 3 to 6 meters), record its nearest neighbor. If
a gorilla is able to see another gorilla indicate LOS (line of sight) next to the ID.
Su/Sh/Oc: If the animal is sitting in the sun during your sample write Su. Write Sh if the animal is in the shade and Oc if it is cloudy, foggy, or generally overcast.

Comments: Record anything of note here (i.e. unusual weather, interesting behavior observed just before a scan, visitor dangling into the exhibit, the discovery of an armadillo near the water feature, etc.)

See the two sample scan sheets included.

BEHAVIOR SAMPLING PROTOCOL

**Time per data set:** You will need to allot about 20 to 40 minutes to complete a data set per animal. Arrive about five minutes before you plan to record data and locate animals. Each data set should last from 15 to 30 minutes. Data can be collected as infrequently as once or twice a day or as often as four to five times a day, depending on your research question. Data sets should be separated by a minimum of one hour.

**Before collecting data:** Check for any messages or notes that might indicate a change in the status of the gorilla troop or individual. Then walk around the habitat looking for the animals. It helps to locate as many individuals as possible prior beginning data collection. It also helps to fill out the top of the data sheet prior to starting.

**Collecting data:** When it is time, locate your target individual or group. If you are collecting data on the group or subset of the group, position yourself so you can see as many of the target animals as possible with as little posture adjustment on your part as possible. Start your data set at the predetermined time. Place a tick mark beside the appropriate behavior every time you see it. It is sometimes helpful to divide up the entire data collection period (e.g. 15 minutes) into smaller intervals (e.g. 3 5-minute intervals). Each time the smaller interval passes, start putting the tick marks in the column for the next.

**Post data collection:** Check your data sheets to be sure that everything is filled in correctly. Then take it to a common or agreed upon drop-off place.

Completing the Behavior Sampling Data Sheet

Exhibit: Indicate which exhibits, habitats, enclosures, cages, etc. are available to the animals.

Observer: That's you.

Temperature: Record the temperature.

Date: Indicate the date of the observation.

Visitors: Circle the rank indicating the number of visitors that are around the gorilla habitat. The range is from 0 to 3 (near riot). Most busy weekends are about a 2.

Time: This is the time that you actually take the sample.

Behavior: Place a tick mark beside the appropriate behavior each time it is performed.

Interval: You will collect data for a predetermined period of time (e.g. a total of 30 minutes or 20 minutes). This time can be divided up into shorter intervals if you like. Just
remember to move to the column representing the next interval when it is appropriate.

Comments: Record anything of note here (e.g. unusual weather, interesting behavior observed just before a scan, visitor dangling into the exhibit, etc.)

Summation: If you do not have the data set divided into smaller intervals, count how often each behavior occurred. Put this number under the column labeled frequency. If you do have your data set divided into smaller intervals, also count the number of in different cells in which the behavior occurred (these data are actually equivalent to 1/0 sampling). Put this number in the column labeled cells.

---

**An Ethogram: What It Is, Why You Need it, How to Write One**

As we all know, behavior is actually an unbroken series of movements and events. However, to make sense of it, it helps to divide this series into discrete units. These units are then measurable. You can count them (frequency), time them (duration), see how long it takes for an animal to demonstrate them (latency), or see how often one behavior follows another (sequence). You can even start to objectively and systematically assess the impact of environmental, developmental, social, etc. influences on them. Sometimes these units are very easy to identify. For example, it is relatively easy to notice when an animal stops traveling and begins to rest. Some units are much more difficult. It doesn't matter how easy or hard the units are to recognize, describing them in proper detail and unambiguously is very important. This is one of the goals of an ethogram.

An ethogram has been defined as a catalogue of descriptions of the discrete, species-typical behavior patterns that form the basic behavioral repertoire of the species (Lehner, 1987), or a complete behavioral vocabulary of a species (Harre and Lamb, 1986). It is not a description of the behavior we wish to observe for a particular study. That is a subset of behavior derived from an ethogram—a topical ethogram. It is not requisite that a researcher develop an entire ethogram before selecting a subset of behaviors to study. Many researchers have published comprehensive ethograms for many species. It is always advisable to refer to and use these resources. This is particularly true for the great apes, because very little great ape behavior remains undescribed. Using an already developed ethogram will save an enormous amount of time and energy, and it is well worth it to do a little archival research to see what is already out there. However, if a researcher feels a compulsion to develop his or her own ethogram or redefine a particular subset of behaviors, it is important to consider the following points.

An ethogram (topical or not) should be as "mutually exclusive" (the animal can be described as doing only one thing at a time) and "exhaustive" (the behavioral units all added up account for 100 percent of an animal's time) as possible. The mutual exclusivity rule is rather problematic with great apes. There is some obviously mutually exclusive behavior. Clearly, one cannot run and sit at the same time. It doesn't take long, however, for even the casual observer to realize that great apes are quite capable of simultaneously executing multiple separate and apparently discrete behaviors (much like many of us can sit upright and type into a computer while talking on the phone and scratching one foot with the other). These combinations probably don't warrant their own description and name--these can be difficult to categorize.
Every nuance of behavior does not need to be described in a vain effort to account for every behavioral possibility. There are between 8 and 12 broad categories of behavior (depending on one's lumping or splitting tendencies) into which all other behavioral acts can be grouped (as one example: Ingest, Locomotion or Travel, Self involved, Environment oriented, Inactive, Social affinitive, Social agonistic, and Unknown). Behaviors in the large categories can then be divided into smaller and more detailed units as needed. There is no reason why the behaviors of interest cannot be described and studied in great detail while the other (less interesting at the time) behavior remains generally described and studied or not studied at all. Even when defining the behaviors of interest, degree of detail must be tempered with the ability to clearly distinguish one behavior from another. All of this is essential in order to attain reliability within your own observations, attain reliability between different observers, allow for independence among the behaviors studied, allow independent researchers to replicate or build upon your work, and, most importantly, answer the research question.

When developing an ethogram, Martin and Bateson (1993) recommend that researchers:

1. Use enough behavioral units and describe behavior in enough detail to answer the research question.

2. Define each behavioral unit precisely and summarize as much relevant information as possible about the behavior. Each unit of behavior to be measured should be clearly, comprehensively, and unambiguously defined. These definitions should be understood by others and each unit should be distinguishable from all other units. Definitions can be empirically or functionally described. To start with, all of the definitions should be empirical. This means that you actually describe the physical actions or motions of the animal, but you do not make any assumptions about the functions of a behavior. Later, you can assign functions for each behavior. Behaviors with similar functions can be considered to be in the same behavioral category. An example of an empirical description might be: "Mouth opening gradually, it remains fully open for about two seconds then rapidly closes. The neck muscles are tense, the head is drawn back, the chin is pointed upwards but not quite straight up. When the mouth is open the tongue is pulled back into the mouth. The lips are drawn back and the teeth (especially the canines) are fully exposed." This will be called a yawn.

3. Behavioral categories should be independent of one another (should not allow the researcher to measure the same thing two different ways).

4. All units within a category should share the same properties (various types of travel, ways to groom, modes of rest, etc.)

We would add that a taxonomic approach to building your own ethogram or reconfiguring someone else's can sometimes be very helpful. This means that behavior is broken down from broad into increasingly more narrow categories. The researcher can then select the level of behavioral analysis within each category of behavior. Of course, this approach is not very useful if the function of the behavior of interest is unknown, ambiguous, or multiple.
example of a taxonomic approach to describing ingest behavior, without the accompanying
descriptions, might be:

INGEST
Forage
Process
  open with own body
teeth
hands or feet
other
smash
drop from a height
hit with an object

You will often have a behavior that does not fit clearly into one category or fits into
multiple categories. A good example of this is the primate yawn or gorilla chest beat. If you are
interested in this type of behavior, it is important to describe these behaviors particularly
carefully, including what was happening when the behavior occurred. A word about
anthropomorphism: it is natural for us to explain and try to understand what animals do in terms
of ourselves. We seem to think that animals are motivated, saddened, or satisfied with the same
things that we are. This may or may not be true, although it is becoming more and more popular
to accept anthropomorphic explanations. It is important to remember, however, that most
animals don't have the same sensory apparatus that we do. Most cannot see, hear, taste, smell, or
feel the world the way we do. Additionally, primates have vastly different behavioral, social, and
environmental histories. It is, therefore, best to keep our own feelings and assumptions on hold
as much as possible.

DATA ANALYSIS

When you have carefully considered and developed a research question, gotten
background information from the library, selected and defined the behavior of interest, selected
your sampling and recording techniques, and collected the data in an unbiased and accurate way,
you are then ready to summarize, or analyze, your data. In general, you can provide basic
answers to most simple research questions using what are referred to as "descriptive statistics";
that is, averages (referred to as "means"), ranges of values, percentage of time spent in particular
behaviors or in particular locations, and so on. To do these types of analysis, sophisticated
statistical analyses are not required. In many cases, however, more thorough analyses may be
appropriate. Further, there may be times when you just are not certain what types of analysis or
summary are required to answer your question. Many volumes have been written about statistical
analysis; this volume clearly is not the forum to provide such an explanation. We recommend
that for help in this area that you consult with someone from a local university, or contact any of
the individuals listed in the Appendix.


GORILLA BIBLIOGRAPHY

This bibliography includes references presented in this volume, as well as searches performed by the compilers and the Primate Information Center; Regional Primate Research Center SJ-50, University of Washington, Seattle, WA 98195, U.S.A., (206)543-4376.

Compiled by: S. Steele and J. Ogden


Allmond, B.W., Jr.; Froeschle, J.E.; Guilloud, N.B. Paralytic poliomyelitis in large laboratory primates: Virologic investigation and report on the use of oral poliomyelitis virus (OPV)


Bellem, A.; Monfort, S.; Goodrowe, K. Puberty, cyclicity, and pregnancy in gorillas: Monitoring reproductive development, menstrual cyclicity, and pregnancy in the lowland gorilla (Gorilla gorilla) by enzyme immunoassay.


Boer, M. Several examinations on the reproductive status of lowland gorillas (Gorilla g. gorilla) at Hannover Zoo. ZOO BIOLOGY 2(4): 267-280, 1983.

Boer, M.; Janke-Grimm, G. [Behavioral studies of lowland gorillas (Gorilla g. gorilla) in the zoological garden.] ZOOLOGISCHE GARTEN 60(3-4), 137-189, 1990. (German w/ English summary)

deBoer, S.F.; Slangen, J.L.; Van der Gugten, J. Adaptation of plasma catecholamine and corticosterone responses to short-term repeated noise stress in rats. PHYSIOLOGY AND


Bourliere, F. [Ethology and veterinary medicine--primates in captivity: Some problems resulting from their ecology and their behavior.] ANNALES DE MEDECINE VETERINAIRE 120: 29-42, 1976. (French)


Boussekey, M. Behavioral study of a mixed group of gorillas and red-tailed monkeys in the St-Martin-la-Plaine Zoological Park. FOLIA PRIMATOLOGICA 58(3): 166, 1992. (Abstract)


Brinkley, P.; Vande Hei, H.; Evans, S. Fostering King's contentment at Monkey Jungle.


Bush, M.; Custer, R.; Smeller, J.; Bush, L. M. Physiologic measures of non human primates during physical restraint and chemical immobilization. JOURNAL OF THE AMERICAN
Cahill, T. Gorilla tactics. GEO 3 (12): 100-114, 1981.


Carroll, S.A. Social development of infant lowland gorillas (Gorilla gorilla gorilla) and the relation between number of zoo visitors and infant activities—[publ. 1990]. MASTERS ABSTRACTS INTERNATIONAL 29(3): 488, 1991.


Clutton-Brock, T.H. Feeding behaviour of red colobus and black and white colobus in East Africa. FOLIA PRIMATOLOGICA 23: 165-207.


Codner, M.A.; Nadler, R.D. Mother-infant separation and reunion in the great apes. PRIMATES
Coe, J.C. Bringing it all together: Integration of context, content, and message in zoo exhibit design. AAZPA 1982 ANNUAL PROCEEDINGS: 268274, 1982.


Coffey, P.; Pook, J. Breeding, hand-rearing and development of the third lowland gorilla Gorilla g. gorilla at the Jersey Zoological Park. ANNUAL REPORT OF JERSEY WILDLIFE PRESERVATION TRUST 11: 45-52, 1974.


Cole, M. Metro Toronto Zoo's gorilla babies; Their first three years. ANIMAL KEEPERS FORUM.

Cole, M. Examples of tool use in a captive group of western lowland gorillas (Gorilla gorilla gorilla). Presented at the Twelfth Annual Meeting of the American Society of Primatologists, Mobile AL. 1989


Cousins, D. Mortality factors in captive gorillas. 30(3): 5-17, 1979.


Cuspinera, A.J. [Primates -- zoo animals of special rank.] ZOOLOGISCHE GARTEN 52 (5-6): 351-356, 1982. (German)


Demontoy-Bomsel, M.-C.; Berthier, J.L. [Effects of environment on pathological processes in zoo-kept gorilla.] ERKRANKUNGEN DER ZOOTIERE 27: 359-364, 1985. (German w/ French, English & Russian summaries)


Derochette, M. [Gorillas in the territory of Sabunda.] BULLETIN DE LA SOCIETE DE BOTANIQUE-ET DE ZOOLOGIE CONGOLAISES 4: 7-9, 1941. (French)


Dittrich, L. [Experiences with a realistic "jungle house" constructed for great apes in the Hannover Zoo.] ZOOLOGISCHE GARTEN 59(4): 241-263, 1989. (German)


Encke, W.; Gandras, R. [Aspects of ape and monkey keeping in zoological gardens.] ERKRANKUNGEN DER ZOOTIERE 22: 191-193, 1980. (German w/ English, French & Russian summaries)


Fainberg, L.A. [Primatology as a source for sociogenetic reconstructions.] Pp. 113-126 in [BIOLOGICAL PREREQUISITES OF ANTHROPOSOCIOCENESIS], VOL. 2. V.P. Alekseev; M.L. Butovskaya, eds. Moscow, Inst. of Ethnography, USSR Acad. of Sciences 1989. (Russian) (Indexing provided by PIC of IEPT, Sukhumi, USSR)


Fischer, F. Training program to enhance maternal behavior. GORILLA GAZETTE 3(1): 5-6, 1989.


Gewalt, W.; Gewalt, I. [Observations on the development of a 5000 gm gorilla (Gorilla g. gorilla Wyman). (Appendix: Determining the sex of young gorillas from the external genitalia.)] ZOOLOGISCHE GARTEN 29: 212-230, 1964. (German)


Glick, C. Inexpensive recreational opportunities for a gorilla. ANIMAL KEEPERS' FORUM 4: 140, 1977.


Goerke, B.; Fleming, L.; Creel, M. Behavioral changes of a juvenile gorilla after a transfer to a


Golding, R. R. A gorilla and chimpanzee exhibit at the University of Ibadan Zoo. INTERNATIONAL ZOO YEARBOOK 12: 71-76, 1972.

Goldsmith, M.L. Ranging and grouping patterns of western lowland gorillas (Gorilla g. gorilla) in the Central African Republic. GORILLA CONSERVATION NEWS 9: 5-6, 1995.


Graham, C. E. Ovulation time: A factor in ape fertility assessment. AMERICAN JOURNAL OF
Graham, C. E., ed. REPRODUCTIVE BIOLOGY OF THE GREAT APES: COMPARATIVE
(ISBN 0-12-295020-8)

Graham, C.E.; Bowen, J.A., eds. CLINICAL MANAGEMENT OF INFANT APES. New York,

Griede, T., comp. GUIDELINES FOR ADEQUATE HOUSING AND CARE OF NON-
HUMAN PRIMATES IN ZOOS. Amsterdam, National Foundation for Research in

Griede, T.; Magen, W. Using a semi-natural environment and other low cost solutions to
improve captive primate welfare. Pp. 32 in XIIth CONGRESS OF THE INTERNATIONAL
PRIMATOLOGICAL SOCIETY ABSTRACTS SUPPLEMENT. Brasilia, IPS Research
Conservation, 1988. (Abstract)

Grisham, J. Oklahoma City Zoo reports significant birth and acquisition. AAZPA [AMERICAN
ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS] NEWSLETTER 30 (4):

Groombridge, B. (ed.). 1994 IUCN RED LIST OF THREATENED ANIMALS. Gland,
Switzerland and Cambridge, U.K.: IUCN.


Groves, C.P.; Stott, K.W., Jr. Systematic relationships of gorillas from Kahuzi, Tshiaberimu and

(German)

Gucwinski, A. Acclimatization of young lowland gorillas (Gorilla g. gorilla) in the Wroclaw

Guilloud, N. B. The breeding of apes: Experience at the Yerkes Regional Primate Research
Center and a brief review of the literature. ANNALS OF THE NEW YORK ACADEMY OF

Gustavsson, O.E.A.; Bength, O.R.; Serrander, R. An epizootic of whooping cough among

Gutzwiller, A.; Wackernagel, H. [Feeding of monkey groups in Zoological Garden of Basel.] ERKRANKUNGEN DER ZOOTIERE 23: 123-126, 1981. (German w/ English, French & Russian summaries)


Hamburg, D. Recent evidence on the evolution of aggressive behavior. ENGINEERING AND SCIENCE 33: 15-24, 1970


Hardin, C.J.; Danford, D.; Skeldon, P.C. Notes on the successful breeding by incompatible gorillas (Gorilla gorilla) at Toledo Zoo. INTERNATIONAL ZOO YEARBOOK 9: 84-88, 1969.


Hinde, R.A.; Spenser-Booth, Y. The behavior of socially living rhesus monkeys in their first two and half years. ANIMAL BEHAVIOR 15: 169-196, 1967.

Hion, A. [Notes on the rearing of gorillas from Belinga.] BIOLOGIA GABONICA 1: 361-374, 1965. (French)


Hoff, M.P.; Maple, T.L. Post-occupancy modification of a lowland gorilla (Gorilla g. gorilla) enclosure at Zoo Atlanta. INTERNATIONAL ZOO YEARBOOK, in press.


International Air Transport Association. LIVE ANIMALS REGULATIONS (IATA


Jendry, C. Utilization of a surrogate to integrate a hand-reared infant gorilla into an age/sex
diversified group of conspecifics. APPLIED ANIMAL BEHAVIOUR SCIENCE, in press.

Jendry, C.; Absi, A. Gorilla introductions. GORILLA GAZETTE 3(3): 5-6, 1989.


Johnstone-Scott, R.A. The potential for establishing bachelor groups of western lowland gorillas *Gorilla g. gorilla*. DODO: JOURNAL OF THE JERSEY WILDLIFE PRESERVATION


Kagawa, M.; Kagawa, K. Breeding a lowland gorilla *Gorilla g. gorilla* at Ritsurin Park Zoo, Takamatsu. INTERNATIONAL ZOO YEARBOOK 12: 105-106, 1972.


Kalter, S.S. Viral diseases of infant great apes. Pp. 57-106 in CLINICAL MANAGEMENT OF


Kaufman, R. The move. ZOO (Topeka) 17(4): [4-5], 1981.


Kawai, M. Polyspecific association and hybridization in the primate community. SEIRI SEITAI / PHYSIOLOGY AND ECOLOGY JAPAN 24(Spec. no.): S57-S73, 1987.


Keiter, M.; Pichette, P. Surrogate infant prepares a lowland gorilla *Gorilla g. gorilla* for motherhood. INTERNATIONAL ZOO YEARBOOK 17: 188-189, 1977.


Kirchhofer, R. [Rearing of gorillas in zoos and laboratories.] ZOOLOGISCHE GARTEN 38: 73-96, 1970. (German w/ English summary)


Kirchhofer, R. The European Breeding Programme for the western lowland gorilla (Gorilla g. gorilla Savage and Wyman 1847). PRIMATE REPORT (31): 20, 1991. (Abstract)


Kleemann, G. [The embarrassing relations. Chimpanzee-gorilla-orang.] KOSMOS (Stuttgart) 249: 1-86, 1966. (German)


Lasley, B. L.; Hodges, J. K.; Czekala, N. M. Monitoring the female reproductive cycle of great apes and other primate species by determination of oestrogen and LH in small volumes of urine. JOURNAL OF REPRODUCTION AND FERTILITY (Suppl. 28): 121-129, 1980.


Laule, G.E.; Desmond, T.J. Use of positive behavioral techniques in primates for husbandry and


Linden, E. A curious kinship: Apes and humans. NATIONAL GEOGRAPHIC 181(3): 2-45,

Linke, K. [Daily comfort behavior and stretching in anthropoids.] ZOOLOGISCHE GARTEN 50(5): 332-336, 1980. (German)


MacDonald, S. Gorillas' (Gorilla gorilla gorilla) spatial memory in a foraging task. JOURNAL OF COMPARATIVE PSYCHOLOGY. 108(2); 107-113, 1994.


Mace, G.M. Captive breeding and conservation. PRIMATE EYE (29, suppl.): 53-58, 1986.


Mallinson, J.J.C. The breeding of gorillas and orang-utans at the Jersey Wildlife Preservation


Markham, R. Taxonomy and the design of great ape houses. AUSTRALIAN PRIMATOLOGY 1(4): 7-9, 1986.


Meder, A. [Studies of the social development of young lowland gorillas (*Gorilla g. gorilla*) at the Cologne Zoo.] ZEITSCHRIFT DES KOELNER ZOO 28(3): 151-161, 1985. (German w/ English summary)


1990b. (Text in English & German)


Murphy, M. F. Breeding statistics of western lowland gorillas Gorilla g. gorilla in United States zoological parks. INTERNATIONAL ZOO YEARBOOK 22: 180-185, 1982.


Nadler, R. D. Second gorilla birth at the Yerkes Regional Primate Research Center.


Nadler, R. D.; Green, S. Separation and reunion of a gorilla Gorilla g. gorilla infant and mother. INTERNATIONAL ZOO YEARBOOK 15: 198-201, 1975.


Ogden, J.J.; Bruner, G.; Maple, T.L. Factors related to successful use of electric fencing as a


Patterson, F. Can an ape create a sentence? Some affirmative evidence. SCIENCE. 211: 86-87, 1981.


Patterson, F. Gorilla Foundation opens new outdoor quarters. GORILLA GAZETTE 3 (2): 14,


Patterson, F. Mirror behavior and self-concept in the lowland gorilla. paper presented at the American Society of Primatologists Conference, University of California, Davis, 1990.

Patterson, F.; Cohn, R. Language acquisition by a lowland gorilla: Koko's first ten years of vocabulary development. WORD, 42(2):97-143, 1990.


Petiniot, C.; Czheres, A.; Favata, G.; Maple, T.; Lasley, B.L., Czekala, N.M. Reproductive behavioral studies over a five year period on Toledo Zoo gorillas. Paper presented At FERTILITY IN GREAT APES CONFERENCE, Atlanta, Georgia, June 1989.


Porton, I.; White, M.; Berry, B. Social dynamics of a bachelor gorilla group at the St. Louis Zoo. 1992 PROCEEDINGS OF THE GORILLA WORKSHOP, MILWAUKEE, in press.


Prowten, A.W.; Lee, R.V.; Krishnamsetty, R.M.; Satchidanand, S.K.; Srivastava, B.I.S. T-cell


Rensch, B.; Duecker, G. [Manipulatory abilities of a young orangutan and a young gorilla, with remarks on play behavior.] ZEITSCHRIFT FUER TIERPSYCHOLOGIE 23: 874-892, 1966. (German w/ English summary)


Robbins, M. Social relationships among an all-male group of mountain gorillas. 1992 GORILLA WORKSHOP, in press.


Ruebel, A.; Schmidt, C.R.; Guscetti, F. [Specific diseases of hand-raised anthropoid apes in Zurich Zoo.] ERKRANKUNGEN DER ZOOTIERE 32: 7-10, 1990. (German w/ English, French; Russian summaries)

Ruempler, U. The Cologne Zoo diet for lowland gorillas (Gorilla gorilla gorilla) to eliminate regurgitation and reingestion. INTERNATIONAL ZOO YEARBOOK 31: 225-229, 31.

Ruempler, U. [Abnormal behavior of lowland gorillas (Gorilla gorilla gorilla, Savage and Wyman) in the Cologne Zoological Garden during changes in feeding routine.] ZEITSCHRIFT DES KOELNER ZOO 33(2): 75-84, 1990. (German w/ English summary)


Rumbaugh, D.M. First year of life...the behavior and growth of a lowland gorilla and gibbon. ZOONOOZ 39(7): 8-17, 1966.


Sabater-Pi, G. [Contribution on the biology of lowland gorillas (Gorilla gorilla Savage and Wyman). Observations of mode of living and of limitations of a family territory.] ZEITSCHRIFT FUER SAEUGETIERKUNDE 25: 133-141, 1960. (German)


Sabater-Pi, J. Exploitation of gorillas (Gorilla gorilla gorilla Savage & Wyman 1847) in Rio Muni, Republic of Equatorial Guinea, West Africa. BIOLOGICAL CONSERVATION 19: 131-140, 1981. (Spanish summary)

Sabater-Pi, J. [Snowflake completes 15 years in the Barcelona Zoo.] ZOO REVISTA DEL PARQUE ZOOLOGICO DE BARCELONA (36): 15-18, 1982. (Spanish)


Sabater-Pi, J.; de Lassaletta, L. [Contribution to knowledge of the lowland gorillas (Gorilla gorilla Savage and Wyman), (Observations on biology of feeding.)] ZEITSCHRIFT FUER SAEUGETIERKUNDE 23: 108-114, 1958. (German)


Sammarco, P. Gorilla keeping at Lincoln Park Zoo. AAZPA REGIONAL CONFERENCE PROCEEDINGS, 1981.


Schildkraut, M.A. The introduction of peer-raised gorillas to a mother/infant pair. AAZPA ANNUAL PROCEEDINGS: 139-142, 1985.


Sicotte, P. Effect of male competition on male-female relationships in bi-male groups of


Snyder, R. L. Strategies for feeding captive omnivorous animals. AAZPA [AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS] NATIONAL

Sommer, R. What do we learn at the zoo. NATURAL HISTORY 81(7), 1972.


Sprachal, M. Current experiences with the constitution of breeding lowland gorilla group (Gorilla gorilla gorilla) in Eastern Bohemian Zoo, Dvur Kralove nad Labem, Czechoslovakia. GORILLA GAZETTE 5(3): 3-6, 1991.


Stevens, A. Gorilla husbandry / enrichment at the Dallas Zoo. Poster presented at the Gorilla Workshop, Columbus, OH, 1990.


Stevens, E.F. Introductory remarks: The importance of research in environmental influences on


Sutherland, R. Space reduction and gorilla socialization. PROCEEDINGS OF THE 1ST GORILLA WORKSHOP. Columbus, Ohio, 1990.

Sutherland, R. Naturalistic variation and gorilla husbandry. PROCEEDINGS OF THE 2ND


Sutherland, R. Reduction of environmentally caused injury and mortalities to infant gorillas. GORILLA GAZETTE. April, 1994.


Tarry, G.; Banks, D.; Randall, P.; McDonald, T. Lowland gorillas at the Calgary Zoo. DINNY'S DIGEST (Spring). 3-5, 1980.


Tutin, C.E.G.; Fernandez, M. Nationwide census of gorilla (Gorilla g. gorilla) and Chimpanzee (Pan t. troglodytes) populations in Gabon. AMERICAN JOURNAL OF PRIMATOLOGY 6: 313-336, 1984.

Tutin, C.E.G.; Fernandez, M.; Parnell, R. Station destudes des gorilles et chimpanzees, Reserve de la Lope, Gabon. GORILLA CONSERVATION NEWS 8: 3-4, 1994.


Van Elsacker, L. The introduction of two adult gorillas (Gorilla g. graueri) into a group. GORILLA GAZETTE 3(2): 7, 1989.

Van Elsacker, L. [The makeup of a group of Graueri gorillas. Introduction to "Mac" (Mukisi) and "Pega."] ZOO ANVERS 55(1): 34-37, 1989. (French)


Walker, E. P. Case of captive animals. SMITHSONIAN INSTITUTION ANNUAL REPORT (1941): 305-366, 1941.


21, 1989.


Weise, R.; Hutchins, M.; Willis, K.; Becker, S. AAZPA ANNUAL REPORT ON


Wiard, J. Reduction of regurgitation and reingestion (R&R) in lowland gorillas at the Oklahoma City Zoo. GORILLA GAZETTE 6(3): 6-7, 1992.


APPENDIX

Gorilla Behavior Advisory Group
Directory of Advisors

Compiled by Jackie Ogden and
the Gorilla Behavior Advisory Group (GBAG)

GBAG Members:

Benjamin Beck, Ph.D.  Donna Fernandes, Ph.D.  Ingrid Porton
Cynthia Bennett, Ph.D.  Ken Gold, Ph.D.   Jill Mellen, Ph.D.
Cathy Cox, Ph.D.  Charlene Jendry  Jackie Ogden,
Ph.D.  Thaya DuBois  Kyle Burks  Suzy Steele

The purpose of this directory is to provide a mechanism for sharing expertise in various areas related to behavior and husbandry in gorillas. These individuals have all expressed willingness to share their experience with anybody in need of information or advice. This list includes both GBAG members and other experts that were recommended by GBAG members. It should in no way be considered exhaustive; the list of people with expertise in these areas clearly could have been considerably longer. Further, this should be considered a working draft; additions or comments should be forwarded to Jackie Ogden.

The directory is organized first by topic; following this is a directory with complete information on contacting these individuals.
## Gorilla Behavior Advisory Group

**Directory of Advisors**

### BY TOPIC

#### Abnormal behavior
- Cynthia Bennett, Ph.D.
- Thaya duBois
- Ken Gold, Ph.D.

#### All-male groups
- Ingrid Porton

#### Basic husbandry
- Beth Armstrong
- Cynthia Bennett, Ph.D.
- Melanie Bond
- John Fried
- Ingrid Porton
- Peggy Sexton
- Rob Sutherland
- Meg White

#### Birth management/hand-rearing
- Ken Gold, Ph.D.
- Barb Jones
- Dusty Lombardi
- Ingrid Porton

#### Daily record keeping
- Melanie Bond
- Ingrid Porton
- Peggy Sexton

#### Enclosure use/evaluation
- Cynthia Bennett, Ph.D.
- Donna Fernandes, Ph.D.
- Ken Gold, Ph.D.
- Jackie Ogden, Ph.D.
- Suzy Steele

#### Enrichment
- Cynthia Bennett, Ph.D.
- Thaya duBois
- John Fried
- Ken Gold, Ph.D.
- Ingrid Porton
- David Shepherdson, Ph.D.
- Rob Sutherland

#### Human/animal interactions
- Cathleen Cox, Ph.D.
- Charlene Jendry
- Jackie Ogden, Ph.D.

#### Infant development
- Thaya duBois
Ken Gold, Ph.D.

Research design/methodology  Cathleen Cox, Ph.D.
                               Cynthia Bennett, Ph.D.
                               Jackie Ogden, Ph.D.
                               Behavior/Husbandry Scientific Advisory Group,
                               Jill Mellen, Ph.D.; Kathy Carlstead, Ph.D., Co-chairs

Social behavior             Cathleen Cox, Ph.D.
                               Ken Gold, Ph.D.
                               Charlene Jendry
                               Beth Armstrong
                               Thaya duBois
                               Cynthia Bennett, Ph.D.
                               Suzy Steele
                               Ingrid Porton

Socializations/introductions Beth Armstrong
                               Cynthia Bennett, Ph.D.
                               Kyle Burks
                               Thaya duBois
                               Donna Fernandes, Ph.D.
                               Ken Gold, Ph.D.
                               Charlene Jendry
                               Jackie Ogden, Ph.D.
                               Ingrid Porton
                               Peggy Sexton

Statistics/data analysis     Kyle Burks
                               Cathleen Cox, Ph.D.
                               Behavior/Husbandry Scientific Advisory Group,
                               Jill Mellen, Ph.D.; Kathy Carlstead, Ph.D., Co-chairs

Survey design               Cathleen Cox, Ph.D.
                               Behavior/Husbandry Scientific Advisory Group,
                               Jill Mellen, Ph.D.; Kathy Carlstead, Ph.D., Co-chairs
Gorilla Behavior Advisory Group
Directory of Advisors

BY NAME:

Beth Armstrong
Gorilla Department
Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive
Powell, OH 43065-0400
614-645-3426

FAX: 614-645-3465

Cynthia Bennett, Ph.D.
Research Zoologist
Dallas Zoo
621 E. Clarendon
Dallas, TX 75203
214-670-6833

FAX: 214-670-7450

Melanie Bond
Zoologist
National Zoo
3000 Block Connecticut Ave NW
Washington DC 20008
202-673-4875

FAX: 202-673-4607

Thaya duBois
Assistant Director of Research
Los Angeles Zoo
5333 Zoo Drive
Los Angeles, CA 90027
213-666-4650 x256

FAX: 213-662-9786

Kyle Burks
Research Associate
Zoo Atlanta
800 Cherokee Ave SE
Atlanta, GA 30315
404-624-5681

FAX: 404-624-5684

Cathleen Cox, Ph.D.
Research Director, Los Angeles Zoo
5333 Zoo Drive
Los Angeles, CA 90027
213-666-4650 x 232

FAX: 213-662-9782
email: Cathleen_Cox@earthspirit.org
Donna Fernandes, Ph.D.
V.P. of Programs
Commonwealth Zoo Corporation
Stone Zoo, 149 Pond St.
Stoneham, MA 02180
617-438-9717

John Fried
Primate Supervisor
Dallas Zoo
621 E. Clarendon
Dallas, TX 75203
214-670-6833

Ken Gold, Ph.D.
Director, Lincoln Park Zoo Gorilla Project
Lincoln Park Zoo
2200 North Cannon Drive
Chicago, IL 60614-3895
312-742-7806

Charlene Jendry
Conservation Outreach Coordinator
Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive
Powell, OH 43065-0400
614-645-3400

Barb Jones
Nursery Staff
Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive
Powell, OH 43065-0400
614-645-3400

Dusty Lombardi
General Curator
Columbus Zoological Society
P.O. Box 400, 9990 Riverside Drive
Powell, OH 43065-0400
614-645-3458

Jackie Ogden, Ph.D.
Children's Zoo Curator
San Diego Zoo
P.O. Box 551
San Diego, CA 92112

FAX: 619-232-4117
email: jogden@sunstroke.sdsu.edu
619-557-3983

**Ingrid Porton**  
Curator of Primates  
St. Louis Zoological Park  
Forest Park, St. Louis, MO 63110  
314-781-0900 x358

**Peggy Sexton**  
Lead Keeper  
San Diego Wild Animal Park  
15500 San Pasqual Valley Road  
Escondido, CA 92027-7017  
619-747-8702

**David Shepherdson, Ph.D.**  
Metro Washington Park Zoo  
4001 SW Canyon Road  
Portland, OR 97221-2799  
503-226-1561

**Suzy Steele**  
Mammal Technician  
Dallas Zoo  
621 E. Clarendon  
Dallas, TX 75203  
214-670-6833

**Rob Sutherland**  
Keeper  
Calgary Zoo  
P.O. Box 3036, Station "B"  
Calgary, Alberta, Canada T2M 4R8  
403-232-9300

**Meg White**  
Keeper  
St. Louis Zoological Park  
Forest Park  
St. Louis, MO 63110  
314-781-0900