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The effect of physical environment on the behavior of captive chimpanzees : a comparison of three Northern California zoos

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**THE EFFECT OF PHYSICAL ENVIRONMENT ON THE
BEHAVIOR OF CAPTIVE CHIMPANZEES:
A COMPARISON OF THREE NORTHERN
CALIFORNIA ZOOS**

**A Thesis
Presented to
The Faculty of the Department of Biological Sciences
San Jose State University**

**In Partial Fulfillment
of the Requirements for the Degree
Master of Arts**

**by
Julie A. Bitnoff
May 1996**

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ABSTRACT

THE EFFECT OF PHYSICAL ENVIRONMENT ON THE BEHAVIOR OF CAPTIVE CHIMPANZEES: A COMPARISON OF THREE NORTHERN CALIFORNIA ZOOS

by Julie A. Bitnoff

The purpose of this study was to determine the effect of different environments on the behavior of three groups of captive chimpanzees. The exhibits at San Francisco, Oakland, and Sacramento Zoos were compared using 23 variables reflecting space, structural features, and habitat complexity. Social behavior, location, and feature use were measured by instantaneous scan sampling. Chimpanzees at San Francisco and Sacramento, but not Oakland, were off ground significantly more than on ground, although the amount of off ground substrate available was highest at Oakland. Perimeters and caves were favored, and hiding behavior was notable at each zoo. Frequency of leaning, suspending, climbing, and manipulating was low at all zoos, and perching was high, despite varying amounts of structures enabling those uses. Device use was highest at San Francisco, where more food enrichment devices and manipulable objects were available. Chimpanzees were publicly-oriented and off exhibit significantly more at San Francisco, perhaps due to lack of an effective barrier and appropriate hiding places.

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Lastly, I dedicate this study to the chimpanzees, who live out their lives in captivity the best that they can, with what they're given. May conditions for them be the best possible, everywhere.

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Introduction

In the past two decades there has been an enormous wealth of research done on primate behavior, in part prompted by Jane Goodall's successful observations of wild chimpanzees at Gombe National Park. However, much of the early research on captive primates was precipitated by a desire to understand human psychological processes. Only recently has the application of behavioral knowledge of primates to their welfare in captivity become an important issue, although this idea is not new. In 1925, Robert M. Yerkes wrote of the essentials of success in keeping and breeding the higher primates: reasonably spacious quarters and adequate resources and opportunity for work and play, among others. Sixty years later, the full thrust of Yerkes' advice began to be realized. In 1985, Congress and the President amended the Animal Welfare Act to include a provision for "a physical environment adequate to promote the psychological well-being of primates." Primate management has become an applied science, known as "applied primatology" (Maple and Finlay, 1986). Accompanied by the emerging field of "zoo biology", applied primatology will provide the scientific basis for the optimal and appropriate care of primates in zoos and laboratories.

Optimally, there are four basic functions of the zoo animal habitat: to provide space adequate for normal locomotory behavior and social distance; to provide opportunity for purposeful activity and social interaction with conspecifics; to provide for public viewing and education; and to maintain separation from the zoo public for the safety and mental well-being of the animals (Maple, 1979). Fulfillment of these functions should keep a captive population of animals healthy and breeding. Unfortunately there are still many non-human primates in zoo habitats built earlier in this century. These zoos often attempted to display as many different species as possible ("postage stamp collections") and in such a way that zoo visitors could get as close to the animals as safely possible. The resulting "hard architecture" was small cages of concrete floors and steel bars, or piles of concrete blocks surrounded by a moat ("monkey islands"). Often built as Works Progress Administration (WPA) projects, they reflected little or no thought to the animals' behavioral needs or to simulating the animals' natural environments.

In addition to the Congressional mandate of 1985, there are numerous reasons to improve the captive environments of non-human primates. Providing for their physical, social, and psychological well-being will undoubtedly increase breeding success. Habitats that elicit species-typical behaviors will also promote human appreciation for the animals. Both of these ramifications further the conservation efforts of zoos. Over the past several years, the zoological community has begun the process of "naturalizing" and "enriching" habitats. Studies assessing the effects of these habitats on chimpanzees are few. However, in one study chimpanzees that were moved from a laboratory environment to a naturalistic man-made island showed dramatic reduction in stereotyped and self-directed behavior and increases in activity and environmental manipulation (Clarke et al., 1982). Providing increased space and complexity in the form of a large playground gave similar results (Brent et al., 1991; Eichberg et al., 1991). The provision of vertical partitions, above-floor benches, and uprooted trees resulted in more time spent off ground (Traylor-Holzer and Fritz, 1985; Maki and Bloomsmith, 1989), a behavior typical of chimps in the wild. Earth mounds, boulders, cement culverts, and multiple small areas create complexity and may aid in providing cover from cagemates or escape from public view (Maple, 1979; Traylor-Holzer and Fritz, 1985; Maple and Finlay, 1989).

In Northern California, three zoos have groups of captive chimpanzees, housed in quite different enclosures. The geographic proximity of these zoos, coupled with their participation in the ChimpanZoo program of the Jane Goodall Institute (see Appendix), provides a unique opportunity to examine the possible effects of environment on behavior. The purpose of this study was to compare the behaviors of chimpanzees at San Francisco Zoo, Oakland Zoo, and Sacramento Zoo in order to evaluate the effect, if any, of these different habitats. The goal of this study and others like it is ultimately to make recommendations to zoos regarding appropriate habitat design and successful enrichment, for the optimum well being of their captive non-human primates and the education of their patrons.

Methods

Eleven chimpanzees (*Pan troglodytes*) housed in social groups of three to four at the three zoos were the subjects of this study. Table 1 shows the summary biographies of these chimpanzees. In addition, a nursing infant male was housed at Oakland Zoo, but its behavior was not sampled. (His volitional use of the habitat was minimal, and his activities and behaviors were strongly controlled by Fran, his mother.)

Table 1. Subject Information

Chimp	Sex	Age	History
San Francisco			
Cobby	Male	31	Wild caught; formerly with circus (?); came to SF Zoo at age 9
Talullah	Female	33	Wild caught; private pet until age 9
Minnie	Female	23	Wild caught; donated to zoo at age 2
Maggie	Female	21	Wild caught; donated to zoo at age 1
Oakland			
Larry	Male	27	Wild caught for research at Stanford; moved to zoo at age 4
Fran	Female	15	Captive born in Colorado zoo; moved to Oakland Zoo at age 12
Abby	Female	8	Captive born in Indiana zoo; moved to Oakland Zoo at age 4
Sacramento			
Sam	Male	42	Wild caught; arrived at Sacto Zoo at age 3
Josie	Female	27	Wild caught; arrived at Sacto Zoo from Lodi Zoo at age 23
Joey	Male	27	Wild caught; arrived at Sacto Zoo at age 4
Judy	Female	27	Wild caught; arrived at Sacto Zoo at age 4

The three chimpanzee habitats are quite different, both in size and features. The grotto at San Francisco Zoo (one of three that house the zoo's great apes and share a common night house), built in the 1930's, is a 81 m² cement island which slopes down into a 4 m deep empty moat. A wooden "jungle gym" was later constructed on the island by community volunteers (Figs. 1, 4). The structure is approximately 6 m across and 4.5 m high, and consists of six

platforms, eleven posts, two ladders, three cargo nets, and a number of ropes, tires, and chains. There are also several large rocks, cement posts, and a metal crawl tube in the grotto. Two or more plastic garbage cans were placed in the exhibit, and a food barrel (designed to elicit "termite fishing" behavior as seen in the wild) on one of the platforms was filled during the study period with a tray of cereal once a week. Various other food treats and browse are placed in the habitat about three times a week. There are no plants or soil, and no cage walls or ceiling. The public views the chimpanzees from behind a railing 6 m away. A 4.8 m bridge leads from the island to the night quarters, which were opened after morning cleaning and generally remained open all day. Chimpanzees were on exhibit from 1000 to 1630 hours daily.

The enclosure at Oakland Zoo, built in 1988, is a 330 m² grassy area with 7.3 m high mesh and glass walls, mesh ceiling, and over 82 m of supporting girders (Figs. 2, 5). Inside is a wooden "jungle gym" (5.9 m long, 2.9 m wide, and 4.3 m high) of 6 vertical and 2 diagonal posts, 6 horizontally propped logs, and cargo netting suspended and draped within it. Ten huge boulders (averaging 3.8 m³) provide climbing opportunities and hiding places, and a rocky stream and pond lead to a cave. This recessed cave, measuring 3.2 m² in area and 0.8 m high, contains numerous large rocks and provides shady refuge. Wild grasses and approximately fifty other shrubs and perennials of at least six different species cover a moderately sloping ground of dirt and sand. An artificial termite mound (filled with peanut butter) and a peanut dispenser puzzle were filled about four times a week during the study period, and other snacks and enrichment were provided on occasion. The public views the chimpanzees from behind a railing set one meter back from the cage. Night quarters were never open to the chimps during zoo hours. Chimpanzees were on exhibit from 0900 to 1600 hours daily.

Sacramento Zoo's chimp habitat, built in 1986, is a 194 m² bamboo "jungle" with 3.7 m high plaster and glass walls (Figs. 3, 6). The enclosure is elliptical with a domed mesh ceiling 8.2 m high at the center. Where the thick plaster wall meets the mesh of the dome, a steep "ledge" is formed and serves as a perch for the chimps. Four caves, ranging from 2.2 m² to 9 m² in area and 2.3 m high, provide refuge from conspecifics and from public view. Four dead tree trunks, each with several snags and branches, are secured upright against the ceiling or

wall, and two logs are propped horizontally amongst them. Over 91 m of rope (used by the chimps for climbing, traveling, and displays) is looped, knotted, and suspended from the ceiling and trees. A recycling waterfall/stream/pond system provides aesthetic value. Thirteen rocks, three boulders, and one long log are distributed amongst a thick forest of bamboo and a dozen other species of plants on a flat dirt ground. A termite mound was filled with honey, mustard, or yogurt about five times a week during the study period, and various enrichment snacks were tested on weekdays. The public views the chimpanzees through two large glass windows, each 2.3 m high and 9.1 m wide. Night quarters were opened after morning cleaning and generally remained open all day. Chimps were on exhibit to the public from 0900 to 1600 hours daily. Halfway through this study, zoo management began granting the animals all night access to the exhibit after their evening meal in the night quarters. Summer evenings in Sacramento are quite warm, and it was felt that the chimpanzees would benefit from being locked up less in the night quarters.

These three physical environments were quantitatively and qualitatively defined using twenty-three environmental variables that reflected spatial and structural features. Objective descriptions of the variables were made in order to accommodate and compare fairly those three quite different zoos, and to allow for the possibility of extending this study to future research sites. These particular variables assessed the habitat's provision for amount of space; off ground travel, brachiating, and climbing opportunities; escape from public view and from other chimps; objects and plants (including manipulable ones); and barrier type, among others. A comparison of those environmental variables is presented in Table 2.

Using an instantaneous scan sampling method (Altmann, 1974), three types of behavioral data (listed below) were recorded for each chimpanzee, at 2 minute intervals, for 90 minutes. Three of these 90 minute sessions were conducted per day, and eighteen days were spent at each zoo, for a total of about 81 hours of observations of each group of chimpanzees. Observation days at each zoo were sequenced randomly, and an attempt was made to observe all days of the week and all zoo hours equally. However, certain hours on some days at Oakland and Sacramento Zoos had to be avoided, due to other enrichment studies, public education activities, and nearby construction work that

greatly affected chimpanzee behavior. Data collection was done between 1 July 1990 and 29 September 1990, a season when weather was optimal and public attendance at zoos was high. A sample data collection sheet is in the Appendix. Three types of behavioral variables were sampled:

1. **Location.** The horizontal and vertical position of the chimpanzee within the habitat. A three dimensional grid was developed, dividing each zoo habitat into sites, identified by a number and letter(s). Portions of these grids are shown in the habitat maps, Figs. 4 - 6. Other site designations are shown in Table 3. These data measured site and space utilization, and reflected preferences for center, perimeter, off ground, and certain areas in the habitat.
2. **Feature Use.** The touching of, leaning against, suspending from, climbing upon, manipulating of, perching upon, and hiding behind any physical feature of the habitat. (For more detailed definitions of these feature uses, see Appendix). These data measured use of habitat structural features, and reflected occurrences of behaviors typical of chimpanzees in the wild, such as arboreal locomotion, foraging, and conflict avoidance.
3. **Social Behavior.** One hundred eighty nine specific behaviors of each chimpanzee were recorded, using an ethogram modified from that defined by Goodall in research at Gombe (Goodall, 1984) and from that used by the ChimpanZoo project in U.S. zoos (JGI, 1991). It is considerably shorter than the Gombe glossary because the intent was not intensive observation of any one type of behavior, but observation of a wide range of behaviors that would occur in diverse zoo enclosures. Behaviors that are unique to the zoo setting have been added. The ethogram is detailed in Table 4. Behaviors fall into such general, non-mutually exclusive categories as Affinitive, Aberrant, Agonistic, Food Related, Solitary, Inactive, Device & Object Use, Public Oriented, Parenting, and Traveling. (Those behavior categorizations are included in the Appendix).

Fig. 1. San Francisco Zoo Chimpanzee Grotto

Fig. 2. Oakland Zoo Chimpanzee Habitat

Fig. 3. Sacramento Zoo Chimpanzee Habitat

Table. 2. Comparison of Environmental Variables at the Three Study Zoos

VARIABLE	SAN FRANCISCO	OAKLAND	SACRAMENTO
Access to Night Quarters/ # of entryways	yes/1	no	yes/1
Horizontal Ground Area	81.3 sq. m	330.91 sq. m	194.22 sq. m
Number of Reclinable levels or perches off ground	9	17	6
Area of Reclinable levels off ground	22.14 sq. m	29.22 sq. m	6.94 sq. m
Maximum Height Attainable	4.45 m	7.35 m	7.68 m
Vertical Climbing Area • mesh cage walls • mesh cage walls plus other vertical	0 sq. m 5.92 sq. m	381.1 sq. m 415.57 sq. m	177.17 sq. m 211.47 sq. m
Area Below Ground Level	282.47 sq. m	0 sq. m	0 sq. m
Suspensory Locomotion • area of ceiling, other • total length of girders, ropes, etc. • no. of such girders, etc.	1.54 sq. m 9.75 m 2	352.56 sq. m 82.64 m 14	259.09 sq. m 95.71 m 31
Off Ground Substrates (sit- ting, walking) • total length • number of such substrates	14.28 m 23	87.17 m 68	93.37 m 32
Number of Fixed Objects at ground level	25	71	24
Number of Semi-fixed/ manipulable objects	21	2	22
Number of Live Plants	0	50+	50+
Number of Plant Species	-	6+	11+
Number of Potentially Edible plants	-	53+	59+
Ground Surface • Description • Hardness • Dampness • Edibility	cement very hard dry, w/puddles nonedible	mostly grass soft dry to moist edible	mostly dirt medium hard moist to soaked edible
Water Features • type • number	stable 1	flowing 1	flowing 2
Distance from Public • minimum - maximum • average	6.1m - 20.72m 13.41 m	0 m - 12.84 m 6.42 m	0 m - 12.61 m 6.31 m

Table 2, cont'd.

VARIABLES	SAN FRANCISCO	OAKLAND	SACRAMENTO
Type of Space Barrier from public	none (moat)	penetrable (wire cage mesh)	non-penetrable (glass)
Visual Access by Public (number of hiding places)	± 15	± 7	20+
Continuous Access by Chimps to each other	yes	yes	yes
Ground Complexity	flat, and steeply sloped	flat, and moderately sloped	flat
Number of Cul-de-sacs (where a chimp could be trapped by another)	1*	2	2
Food Dispensing Devices <ul style="list-style-type: none"> •number •availability (times per week) 	2 4	3 5	2 5

*only when door to night quarters is closed.

Fig. 4. San Francisco habitat map, showing partial grid designation

Fig. 5. Oakland Zoo habitat map, showing partial grid designation

Fig. 6. Sacramento Zoo habitat map, showing partial grid designation

Table 3. Site Designations

Oakland Zoo

<u>Level</u>	<u>Described Area</u>
0	Ground level. Chimp has feet, buttocks, or at least one shoulder being supported by the ground.
1	Trunk of chimp is between ground and first horizontal reinforcement beam in the cage wall, but no part of the chimp's body is being supported by the ground. Includes sitting on termite mound, on waterfall rocks, on some of the boulders, clinging to the cage wall, and possibly sitting on any of the six lowest logs of the jungle gym (depending on trunk position).
2	Trunk of chimp is between the first and second horizontal beams. Includes clinging to walls, sitting on boulders, sitting on the two highest logs and possibly the six lower logs of the jungle gym (depending on trunk position), and sitting atop any of the 3 lower vertical posts of the jungle gym.
3	Trunk of chimp is between the second beam and the ceiling girders. Includes hanging from a girder, clinging to walls, and sitting atop any of the 3 higher vertical posts of the jungle gym.
4	Trunk of chimp is above ceiling girder level. Includes sitting, standing, walking, and reclining on a girder; and suspending from the ceiling such that the trunk is above the level of the girders.

San Francisco Zoo

<u>Level</u>	<u>Described Area</u>
-2	Moat bottom (gutter)
-1	Slope, or on stairway down into moat.
0	Ground level. Chimp has feet, buttocks, or at least one shoulder being supported by the ground.

Table 3., cont'd.

San Francisco Zoo, cont'd.

<u>Level</u>	<u>Described Area</u>
1	On platform 1, on any of the rocks, on any of the cement posts, or on any other structure such that the chimp's trunk is within the vertical level defined by these features; no part of the chimp's body is being supported by the ground.
2	On platforms 2, 3, or 4; on the back net; on the front/lower half of the front net (such that the chimp's trunk is at a level defined by these features); on the horizontal metal bars; on the wooden ladder; on top of the food barrel; on the stairway's metal post.
3	On platforms 5 or 6; on the back/upper half of the front net (such that the chimp's trunk is at a level defined by these features); on tops of 5 posts (two in front, one on far left, one on far right, and one in far back in quadrant C).
4	Atop any of the 5 highest posts, or upon the tires fastened to those posts.

Sacramento Zoo

<u>Level</u>	<u>Described Area</u>
0	Ground level. Chimp has feet, buttocks, or at least one shoulder being supported by the ground.
1	Trunk of chimp is between the ground and the ledge (ledge is where plaster "rock" wall meets cage mesh), but no part of the chimp's body is being supported by the ground. Includes sitting on any rock; sitting on/hanging from a rope such that the trunk is below ledge level; upon Tree C; upon the horizontally placed log wedged between Trees A and B.
2	Trunk of chimp is <u>at</u> ledge level, or within 0.3 m of ledge. Includes sitting or "walking" on ledge; on the horizontally propped log from Tree D to the ledge; sitting on/hanging from a rope such that trunk is within 0.3 m of ledge level.

Table 3., cont'd.

Sacramento Zoo, cont'd.

<u>Level</u>	<u>Described Area</u>
3	Trunk of chimp is more than 0.3 m above ledge level. Includes climbing on or clinging to the dome mesh; climbing up Trees A, B, or D such that trunk is >0.3 m above ledge level; sitting on the short horizontal branch that protrudes from Tree B; sitting on the steel rings that protrude from the center poles.
4	Trunk of chimp is at or near ceiling level. (Ceiling begins approximately 2/3 of the way from the ledge to the ceiling crossbrace.) Includes sitting atop Trees A, B, or D where they are propped against the ceiling; sitting on or hanging from a rope such that the trunk is within the ceiling designation; clinging or suspending from the ceiling mesh.

Center and Perimeter (Oakland and Sacramento Zoos only)

Center areas are those more than arm's reach of the walls.

Perimeter areas are those within arm's reach of the walls.

Table 4. Ethogram of Behaviors

A recorded behavior consists of a context (first two letters) followed by a specific behavior (next 4 - 5 letters). (See Table 8.) Contexts are Affinitive (AF), Agonistic (AG), Mothering/Alloparenting (MA), Publicly Oriented (PU), Solitary/Nonsocial (SO), and Submissive (SU).

Specific Behaviors

ABMV	aberrant movement	CORTG	gymnastic display
ABOR	aberrant oral	CORTL	lead female
ABORC	coprophagy	CORTM	male invite
ABORS	self orality	CORTO	gaze only
ABORU	urine drinking	CORTS	swagger
ABORV	reingest vomit	DRNK	drink
AGRD	aggressive display	DVUS	device/material use
AGRDA	arousal (piloerect, lips compressed)	EMBR	embrace
AGRDC	charge	EXXM	explore/examine/ manipulate object
AGRDI	in-place movement (rock, sway)	FECA	fecal art
ALOP	alloparenting	FOOD	food in hand, mouth, both, or as wadge
APES	appease		
APRO	approach	FORG	forage
ARMS	arm stretch/extend hand	GRAB	grab/push/pull/ drag another
ARMT	arm threat/hit toward	GRMT	groom mutual
ATDS	attacked/displaced	GROT	groom another
AVOD	avoidance	GRRC	groom recipient
AVODF	flight	GRSF	groom self
AVODM	move away	GYMN	gymnastics
BEGH	beg with hand	HNCH	hunch
BEGM	beg with mouth	HOLD	hold/carry/touch/ drag object
BITE	bite	HPSF	hair pluck self
BPST	bipedal stand	IDRC	idle recline
BPSW	bipedal swagger	IDST	idle sit
BPWR	bipedal walk/run	INSP	inspect with finger/ probe/sniff
CARD	carry infant		
CHAS	chase	KISS	kiss
CLNG	cling/hold	MBAT	masturbate
CORT	courtship display	NURS	nurse

Table 4., cont'd.

<u>Specific Behaviors</u>			
NVNQ	not visible: in night quarters	SITT	sitting, while otherwise engaged
PLAY	play social	SLAP	slap/hit/flap/poke
PLAYB	play bite		push
PLAYC	play chase	SLGR	solicit/greet public
PLAYG	play gymnastics	TAKE	grab/steal/take object
PLAYW	wrestle/tickle/poke	TBOD	touch body
PROT	protect, retrieve infant	TFAC	touch face
PSNT	present	THRO	throw
PSNTO	present social	TOTH	touch another
PSNTX	present sexual	TRCL	traverse climb
QDST	quadrupedal stand	VOCA	vocalize
QDWR	quadrupedal walk/run	VOCAP	pant-hoot
		VOCAS	scream
REAS	reassure	VRCL	vertical climb
RECL	reclining, while otherwise engaged	WTCH	watch
SCSL	scratch self		

All data were summed and are presented as percent of time each chimpanzee group devoted to various locations, or percent of the total samples in which a given behavior was recorded (Altmann, 1974). Some of these data were analyzed using the G test, a chi-square test of independence. Significance was defined as $p \leq .025$, to protect against Type 1 errors. After subtracting the instances when chimpanzees were off exhibit and in the night houses, the total number of samples (i.e. two-minute intervals) (n) was 6,180 at San Francisco Zoo, 7,092 at Oakland Zoo, and 9,024 at Sacramento Zoo.

Results

Location Behavior. Location data for each chimpanzee group are presented in Tables 5, 6, and 7. Not all locations were of equal size or accessibility, nor were they equal in features of interest to the chimps. This difference accounts for the low and zero occupancies of some locations. Chimpanzees at San Francisco spent 61.2% of their time off ground (levels 1 - 4, from low to high); at Oakland they spent 46.6% of their time off ground, while at Sacramento, chimps were off ground 60.9% of the time. The difference between Oakland and the two other zoos is significant ($G = 407.571$, $p < .0001$). (The difference between San Francisco and Sacramento is not significant.) Although incidents of off ground locations were fewest at Oakland, it ranked the highest of the three zoos in total length

Table 5. Location Data for San Francisco Zoo. (n = 6180)

LOCATION	% of time occupied	LOCATION	% of time occupied	LOCATION SUMS	% of time occupied
A -2	0.9	C -2	0.6	All -2	2.2
A -1	0.5	C -1	0.4	All -1	1.5
A 0	5.7	C 0	11.40	All 0	35.10
A 1	2.5	C 1	0.1	All 1	5.9
A 2	24.30	C 2	0.1	All 2	35.40
A 3	0.4	C 3	10.60	All 3	18.40
A 4	0.0	C 4	0.9	All 4	1.5
B -2	0.1	D -2	0.6	All 1-4	61.20
B -1	0.4	D -1	0.3	All A	34.30
B 0	9.5	D 0	8.5	All B	28.20
B 1	0.2	D 1	3.1	All C	24.10
B 2	10.20	D 2	0.9	All D	13.50
B 3	7.3	D 3	0.1	All moat	7.4
B 4	0.5	D 4	0.0		

Table 6. Location Data for Oakland Zoo. (n = 7092)

LOCATION	% of time occupied	LOCATION	% of time occupied	LOCATION	% of time occupied
AC0	0.7	EC0	0.2	IC0	0.4
AC1	0.3	EC1	0.5	IC3	0.0
AC3	0.0	EC2	0.1	IC4	0.6
AC4	0.7	EC3	0.0	IP0	0.7
AP0	0.2	EC4	2.0	IP1	0.3
AP1	0.7	EP0	0.1	IP2	0.0
AP2	0.1	EP1	0.0	IP3	0.0
AP3	0.2	EP2	1.8	IP4	0.0
AP4	0.0	EP3	0.0	JC0	0.6
BC0	0.6	EP4	0.0	JC3	0.0
BC1	0.0	FC0	1.5	JC4	0.6
BC2	0.2	FC1	2.7	JP0	1.1
BC3	0.0	FC2	2.6	JP1	0.1
BC4	3.2	FC3	0.0	JP2	0.0
BP0	0.1	FC4	4.3	JP3	0.0
BP1	0.1	FP0	9.7	JP4	0.0
BP2	2.8	FP1	0.8	KC0	3.0
BP3	0.1	FP2	1.9	KC1	0.0
BP4	0.1	FP3	0.4	KC3	0.0
CC0	0.4	FP4	0.2	KC4	1.2
CC1	0.1	GC0	0.5	KP0	1.3
CC2	0.4	GC1	0.1	KP1	0.1
CC3	0.0	GC3	0.0	KP2	0.1
CC4	1.6	GC4	1.4	KP3	0.0
CP0	1.4	GP0	2.9	KP4	0.0
CP1	0.1	GP1	1.8	LC0	1.6
CP2	0.5	GP2	0.1	LC1	2.3
CP3	0.1	GP3	0.4	LC2	1.8
CP4	0.0	GP4	0.1	LC3	0.0
DC0	1.6	HC0	0.6	LC4	1.4
DC2	0.1	HC3	0.0	LP0	12.50
DC3	0.0	HC4	2.6	LP1	0.4
DC4	0.9	HP0	1.2	LP2	0.3
DP0	0.7	HP1	0.3	LP3	0.1
DP1	0.3	HP2	0.1	LP4	0.0
DP2	0.7	HP3	0.0	Cave	9.9
DP3	0.0	HP4	0.0		
DP4	0.0				

Table 6., cont'd

LOCATION SUM	% of time occupied	LOCATION SUM	% of time occupied	LOCATION SUM	% of time occupied
All 0	43.20	All B	7.0	All I	2.0
All 1	10.90	All C	4.5	All J	2.4
All 2	13.30	All D	4.3	All K	5.6
All 3	1.5	All E	4.8	All L	20.30
All 4	20.90	All F	23.90	All cave	9.9
All 1-4	46.60	All G	7.3	All center	43.00
All A	2.9	All H	4.7	All perim.	46.80

Table 7. Location Data for Sacramento Zoo. (n = 9024)

LOCATION	% of time occupied	LOCATION	% of time occupied	LOCATION	% of time occupied
AC0	3.2	CC2	2.6	EC3	0.1
AC1	0.1	CC3	0.2	EPO	2.2
AC2	0.0	CP0	0.0	EP2	0.6
AC3	0.0	CP1	0.0	EP3	0.0
AP0	0.1	CP2	15.90	EP4	0.0
AP1	0.0	CP3	0.1	FC0	5.2
AP2	9.0	CP4	1.5	FC1	0.1
AP3	0.0	DC0	0.5	FC2	0.0
AP4	0.0	DC1	14.80	FC3	0.0
BC0	0.9	DC2	0.1	FP0	4.9
BC1	0.8	DC3	1.9	FP2	1.1
BC2	0.0	DP0	8.8	FP3	0.0
BC3	0.0	DP1	0.3	FP4	0.0
BP0	0.0	DP2	0.6	Cave A1 lev0	0.7
BP1	0.0	DP3	0.3	Cave A2 lev0	2.2
BP2	7.7	DP4	0.1	Cave A2 lev1	0.0
BP3	0.0	EC0	0.4	Cave C1 lev0	3.5
BP4	0.1	EC1	2.1	Cave C1 lev1	0.4
CC0	1.4	EC2	0.1	Cave C2 lev0	5.1
CC1	0.0				
LOCATION SUM	% of time occupied	LOCATION SUM	% of time occupied	LOCATION SUM	% of time occupied
All 0	39.00	All 1-4	60.90	All E	5.5
All 1	18.80	All A	12.50	All F	11.30
All 2	37.70	All B	9.6	All cave	11.90
All 3	2.8	All C	21.70	All center	34.60
All 4	1.7	All D	27.40	All perim.	53.40

and area of structures and features that enable off ground occupation (see Table 2.). San Francisco ranked the lowest in off ground and suspensory structures, yet it was comparable to Sacramento in percent of time chimps spent off ground. Perimeter areas were occupied more often than center areas at both Oakland and Sacramento zoos, but the preference at Oakland was not as significant as it was at Sacramento ($G = 124.022$, $p < .0001$). (Perimeter and center areas as defined did not exist at San Francisco Zoo.) Cave occupation was fairly high at both Oakland and Sacramento zoos – 9.9% and 11.9% of the samples, respectively. Such areas provided refuge from public view and shady napping places for both groups of chimps. Moat and slope use at San Francisco was considerable – 7.4% of total time. One half of that time, the chimps were actually completely out of view of the public, indicating the moat's importance as a hiding place. Specific sites at each zoo were favored by the animals due to the presence of certain desirable features. Location A2, which was used 24.3% of the time at San Francisco Zoo, contained the largest platform areas (3.6 m²). Areas F and L at Oakland Zoo had a combined occupation of 44.2% of the time due to the presence of a jungle gym, a peanut dispenser, a cool shaded wall nearly out of public view, and proximity to the keepers' entrance to the kitchen. Areas C and D, used for a combined 49.1% of the time at Sacramento Zoo, contained trees and propped logs, and are near the night quarters/kitchen entrance.

Feature Use Behavior. Figure 7 compares feature use behavior at the three zoos. Perching was slightly less at Oakland Zoo despite the greater total length and area of perches and off ground substrates. Perching upon a structure occurred with similar frequencies at San Francisco and Sacramento zoos. This similarity is accounted for by the comparable amount of structures at those zoos that enabled perching (greater number and area of levels for reclining at San Francisco but smaller number and length of ledges, tree branches, and logs for sitting and walking, compared to Sacramento). Touching of an object was highest at Sacramento. Most of this touching occurred with perching, as chimps grabbed onto the cage mesh to stabilize themselves while perching on the narrow ledge (level 2, 37.7% of the time; see Table 7). Touching a feature at Oakland Zoo occurred in 20.2% of the samples, and indeed there was much to touch in that habitat: 71 fixed objects at ground level, 50 or more live plants, and the largest wall area of the three zoos. Suspending from a feature was very infrequent, an

Fig. 7. Comparison of Feature Uses at the Three Study Zoos

expected result at San Francisco where there were very few features from which to suspend, but also low at the other two zoos, despite the fairly large ceiling area and length of ropes and girders. The same trend was observed when relating occurrences of climbing behavior to amounts of climbable features. Leaning against a structure was also rare; many (34%) of the incidents of this at San Francisco were accounted for by one particular chimp at his usual hiding place -- perched on a platform and leaning against the supporting post. Manipulating of

an object was infrequent, being lowest at Sacramento where manipulable objects and food dispensing devices were greatest in number, and somewhat more frequent at San Francisco and Oakland. More manipulation occurred as food dispenser use than as rope swinging, plant stripping, or trash can drumming, for example. Hiding behind a structure was fairly frequent at Oakland and Sacramento (9.7% and 9.4% of samples, respectively). Although Oakland ranked lowest in number of hiding places, clearly those few places were needed and used. Most of the hiding places at San Francisco were in the bottom of the moat, but chimps also found sites on the jungle gym that partially obscured them from public view. Although San Francisco's hiding behavior was significantly lower than the other two zoos ($G = 67.774$, $p < .0001$; no significant difference between Oakland and Sacramento), in fact those animals were out of public view the most (32.5% of samples), in the night quarters.

Behavior. Frequencies of specific behaviors of chimpanzees at the three study zoos are presented in Table 8. Behaviors have also been grouped into ten non-mutually exclusive categories (see Appendix), and those frequencies are presented in Figure 8. Aberrant behaviors were quite low; the slightly higher frequency at the Oakland Zoo is attributable to one chimp (Abby) who was rejected by her mother at age two days, hand reared, and housed alone until arrival at Oakland at age four. Affinitive behaviors were highest at Oakland, 44.7 % of samples, due to the consortship of the adult male and adult female. Very little agonistic behavior occurred at the zoos; however the minor amount (2.6% of samples) at San Francisco was almost entirely directed at the public. Device and object use were significantly different at all three zoos, being highest at San Francisco ($G = 179.270$, $p < .0001$). This is partly due to the high use of the food barrel there and other food and browse-enrichment provided, but also to the use of the tub and garbage can (used as drums) and items thrown from the grotto during aggressive displays at the public. Sacramento Zoo's device and object use was also forage and agonistic-related, but the agonistic portion was very minor (0.5%) and not directed at the public. Oakland Zoo had very few manipulable objects and not all its chimps were adept at or allowed access to the food dispensers (since they were monopolized by Larry, the adult male). Food related behavior was significantly less at Sacramento (6.5% of samples; $G = 85.156$,

Table 8. Behavior Data. (SF, n = 6180; OAK, n = 7092; SAC, n = 9024)

Behavior	% of total samples			Behavior	% of total samples		
	SF	OAK	SAC		SF	OAK	SAC
AF-ABMV	0.0	0.0	0.0	AF-GROT	2.7	1.9	6.0
AF-ABOR	0.0	0.0	0.0	AF-GRRC	2.6	1.7	6.0
AF-ABORC	0.0	0.0	0.0	AF-GRSF	0.3	0.5	0.3
AF-ABORS	0.0	0.0	0.0	AF-GYMN	0.0	0.1	0.1
AF-ABORU	0.0	0.0	0.0	AF-HNCH	0.0	0.0	0.0
AF-ABORV	0.0	0.0	0.0	AF-HOLD	0.4	0.3	0.7
AF-ALOP	-	0.9	-	AF-HPSF	0.0	0.0	0.0
AF-APES	0.0	0.0	0.0	AF-IDRC	2.8	1.1	2.6
AF-APRO	0.1	0.5	0.1	AF-IDST	2.3	8.6	5.1
AF-ARMS	0.0	0.0	0.0	AF-INSP	0.0	0.1	0.1
AF-ARMT	0.0	0.0	0.0	AF-KISS	0.0	0.0	0.0
AF-ATDS	0.0	0.0	0.0	AF-MBAT	0.0	0.0	0.0
AF-AVOD	0.0	0.0	0.0	AF-PLAY	0.0	0.4	0.0
AF-AVODF	0.0	0.1	0.0	AF-PLAYB	0.0	0.6	0.0
AF-AVODM	0.0	0.3	0.0	AF-PLAYC	0.3	0.3	0.0
AF-BEGH	0.0	0.0	0.0	AF-PLAYG	0.0	0.0	0.0
AF-BEGM	0.0	0.0	0.0	AF-PLAYW	0.1	2.0	0.3
AF-BITE	0.0	0.0	0.0	AF-PROT	-	0.1	-
AF-BPST	0.0	0.3	0.1	AF-PSNT	0.0	0.0	0.0
AF-BPSW	0.0	0.0	0.0	AF-PSNTO	0.0	0.0	0.0
AF-BPWR	0.0	0.0	0.0	AF-PSNTX	0.0	0.0	0.0
AF-CARD	-	0.0	-	AF-QDST	0.4	0.7	0.7
AF-CHAS	0.0	0.1	0.0	AF-QDWR	1.2	2.9	0.4
AF-CLNG	0.0	1.1	0.5	AF-REAS	0.0	0.0	0.0
AF-CORT	0.0	0.0	0.0	AF-RECL	0.7	0.1	0.5
AF-CORTG	0.0	0.0	0.0	AF-SCSL	0.0	0.1	0.2
AF-CORTL	0.0	0.0	0.0	AF-SITT	1.9	5.3	2.5
AF-CORTM	0.0	0.0	0.1	AF-TAKE	0.0	0.0	0.0
AF-CORTO	0.0	0.0	0.0	AF-TBOD	0.0	0.1	0.1
AF-CORTS	0.0	0.0	0.0	AF-TFAC	0.1	0.1	0.2
AF-DRNK	0.0	0.0	0.0	AF-TOTH	0.0	0.2	0.1
AF-DVUS	0.4	0.2	0.3	AF-TRCL	0.0	0.1	0.6
AF-EMBR	0.0	0.0	0.0	AF-VOCA	0.0	0.1	0.0
AF-EXXM	0.1	0.2	0.2	AF-VOCAP	0.0	0.0	0.0
AF-FECA	0.0	0.0	0.0	AF-VOCAS	0.0	0.0	0.0
AF-FOOD	0.3	1.3	0.3	AF-VRCL	0.1	0.2	0.1
AF-FORG	0.2	0.4	0.0	AF-WTCH	0.6	5.0	2.3
AF-GRAB	0.0	0.1	0.0	AG-AGRD	0.0	0.0	0.1
AF-GRMT	7.0	7.6	0.8	AG-GRDA	0.0	0.0	0.2

Table 8., cont'd.

Behavior	% of total samples			Behavior	% of total samples		
	SF	OAK	SAC		SF	OAK	SAC
AG-AGRDC	0.0	0.0	0.0	MA-WTCH	-	0.2	-
AG-AGRDI	0.0	0.0	0.1	PU-AGRD	0.0	0.0	0.0
AG-APRO	0.0	0.0	0.0	PU-AGRDA	0.4	0.1	0.0
AG-ARMT	0.0	0.0	0.0	PU-AGRDC	0.0	0.0	0.0
AG-BITE	0.0	0.0	0.0	PU-AGRDI	0.5	0.0	0.0
AG-BPST	0.0	0.0	0.0	PU-ARMT	0.0	0.0	0.0
AG-BPSW	0.0	0.0	0.0	PU-BEGH	0.0	0.1	0.0
AG-BPWR	0.0	0.0	0.0	PU-BEGM	0.0	0.0	0.0
AG-CHAS	0.0	0.0	0.0	PU-BPST	0.0	0.0	0.0
AG-CLNG	0.0	0.0	0.0	PU-BPSW	0.3	0.0	0.0
AG-DVUS	0.0	0.0	0.0	PU-BPWR	0.0	0.0	0.0
AG-GRAB	0.0	0.0	0.0	PU-DVUS	0.2	0.0	0.0
AG-GYMN	0.0	0.0	0.0	PU-GYMN	0.0	0.0	0.0
AG-HNCH	0.0	0.0	0.1	PU-HNCH	0.8	0.1	0.1
AG-HOLD	0.0	0.0	0.0	PU-SLGR	0.2	0.0	0.0
AG-QDST	0.0	0.0	0.0	PU-THRO	0.0	0.0	0.0
AG-QDWR	0.0	0.0	0.0	PU-VOCA	0.1	0.1	0.0
AG-SLAP	0.0	0.0	0.0	PU-VOCAP	0.0	0.1	0.0
AG-THRO	0.0	0.0	0.0	PU-VOCAS	0.0	0.0	0.0
AG-TRCL	0.0	0.0	0.0	PU-WTCH	47.00	34.40	29.10
AG-VOCA	0.0	0.0	0.0	SO-ABMV	0.0	0.6	0.0
AG-VOCAP	0.1	0.0	0.2	SO-ABOR	0.0	2.4	0.0
AG-VOCAS	0.1	0.0	0.0	SO-ABORC	0.0	0.7	0.0
AG-VRCL	0.0	0.0	0.0	SO-ABORS	0.0	0.2	0.0
AG-WTCH	0.0	0.0	0.1	SO-ABORU	0.0	0.0	0.0
MA-APRO	-	0.0	-	SO-ABORV	0.0	0.0	0.4
MA-ARMS	-	0.0	-	SO-AGRD	0.0	0.0	0.0
MA-CARD	-	3.0	-	SO-AGRDA	0.0	0.0	0.0
MA-EMBR	-	0.0	-	SO-AGRDC	0.0	0.0	0.0
MA-GRMT	-	0.0	-	SO-AGRDI	0.0	0.0	0.0
MA-GROT	-	0.8	-	SO-BPST	0.2	1.3	0.3
MA-GRRC	-	0.0	-	SO-BPSW	0.0	0.0	0.0
MA-NURS	-	0.1	-	SO-BPWR	0.0	0.0	0.0
MA-PLAY	-	0.0	-	SO-CLNG	0.0	4.5	0.9
MA-PLAYB	-	0.0	-	SO-DRNK	0.3	0.0	0.0
MA-PLAYC	-	0.0	-	SO-DVUS	3.4	0.8	2.3
MA-PLAYG	-	0.0	-	SO-ELIM	0.1	0.1	0.1
MA-PLAYW	-	0.0	-	SO-EXXM	0.8	1.4	0.7
MA-PROT	-	0.3	-	SO-FECA	0.0	0.1	0.0

Table 8., cont'd.

Behavior	% of total samples			Behavior	% of total samples		
	SF	OAK	SAC		SF	OAK	SAC
SO-FOOD	0.0	0.1	0.0	SO-THRO	0.0	0.0	0.0
SO-FORG	2.8	1.4	0.8	SO-TRCL	0.0	0.0	0.8
SO-GRSF	2.3	1.6	2.9	SO-VOCA	0.1	0.2	0.0
SO-GYMN	0.0	0.7	0.1	SO-VOCAP	0.0	0.0	0.0
SO-HNCH	0.1	0.1	0.1	SO-VOCAS	0.0	0.0	0.0
SO-HOLD	4.3	1.4	3.5	SO-VRCL	0.5	0.8	0.2
SO-HPSF	0.1	0.0	0.0	SU-APES	0.0	0.0	0.0
SO-IDRC	18.20	3.5	22.10	SU-APRO	0.0	0.0	0.0
SO-IDST	31.60	29.40	34.50	SU-ARMS	0.0	0.0	0.0
SO-MBAT	0.0	0.1	0.0	SU-AVOD	0.0	0.0	0.0
SO-QDST	3.6	2.5	1.5	SU-AVODF	0.0	0.0	0.0
SO-QDWR	7.3	6.2	2.7	SU-AVODM	0.0	0.0	0.0
SO-RECL	3.8	0.2	1.4	SU-GROT	0.0	0.0	0.0
SO-SCSL	0.7	0.6	1.0	SU-PSNT	0.0	0.0	0.0
SO-SITT	7.4	10.70	10.10	SU-TOTH	0.0	0.0	0.0
SO-TBOD	0.2	0.2	0.4				
SO-TFAC	0.8	1.0	1.9	NVNQ	32.50	-	3.4

" - " indicates behavior is inapplicable at that zoo.

Context Code: AF = Affinitive, AG = Agonistic, MA = Mothering/Alloparenting, PU = Publicly Oriented, SO = Solitary/Nonsocial, SU = Submissive.

Fig. 8. Comparison of Behaviors by Category

$p < .0001$), compared to 9.5% and 10.3% at San Francisco and Oakland respectively (no significant difference). Oakland and Sacramento had more edible plants and more food dispensing devices. However, not all chimps exhibited equal interest or ability in foraging for food. Idle and inactive behavior was significantly different at all three zoos, being lowest at Oakland ($G = 758.628$, $p < .0001$). Perhaps this is due to the presence of the tirelessly active infant (who kept his parents Larry and Fran active as a result) and to the play behavior of all adult chimps with the infant. Chimpanzees at San Francisco and Sacramento were idle or inactive in 54.9% and 64.3% of samples, respectively. Publicly oriented behavior was significantly different at all three zoos, being highest at San Francisco Zoo ($G = 650.315$, $p < .0001$). There it occurred in 49.5% of samples, of which 47% was merely watching and 2.3% was aggression related (e.g. bipedal swaggering, piloerection, and throwing). Oakland and Sacramento had lower frequencies of publicly oriented behavior, consisting almost exclusively of the more passive watching activity. Solitary behavior was significantly higher at San Francisco and Sacramento zoos -- 94.5% and 93.8% of samples, respectively -- than at Oakland Zoo ($G = 1433.104$, $p < .0001$). Due to the consortship and to the interest value of the infant, solitary behavior was lower at Oakland, even though the adolescent female was almost constantly excluded from affiliation by the two adults. Traveling and movement were fairly low, being only slightly higher at Oakland, 11.1% of total samples (again perhaps due to the infant), and slightly lower at Sacramento, 5% of total samples, despite the large enclosure size and greater number of structures that enable mobility.

Some recorded behaviors were obviously "feature dependent", meaning they required a habitat feature to occur. Those included vertical climb (VRCL), traverse climb (TRCL), clinging (CLNG), device use in some cases (DVUS), explore/examine/manipulate in some cases (EXXM), and gymnastics (GYMN). A comparison of those behaviors at each zoo in relation to the number of features and structures present that enabled them is presented in Table 9. Although those behaviors occurred only rarely, most of them did seem to correlate positively with the amount of structure enabling them. Vertical climbing was highest at Oakland ($G = 43.976$, $p < .0001$), which had the highest amount of vertical structure. However, vertical climbing did not require a vertically oriented structure such as a cage wall, as evidenced by the inter-platform climbing done

Table 9. Comparison of Feature Dependent Behaviors and Quantity of Environmental Variables Enabling Them

BEHAVIOR	SAN FRANCISCO		OAKLAND		SACRAMENTO	
	% of total samples (n=6180)	Amt. of structure enabling the behavior	% of total samples (n=7092)	Amt. of structure enabling the behavior	% of total samples (n=9024)	Amt. of structure enabling the behavior
VRCL	0.6%	5.92 m ²	1%	415.57m ²	0.2%	211.47m ²
TRCL	0%	5.92 m ²	0.1%	415.57m ²	1.3%	211.47m ²
CLNG	0%	7.46 m ² and 9.75m	5.6%	768.13m ² and 82.6m	1.4%	470.6m ² and 95.7m
GYMN	0%	7.46 m ² and 9.75m	0.8%	768.13m ² and 82.6m	0.2%	470.6m ² and 95.7m
DVUS	4%	21 objects 0 plants 8 feeders	1%	2 objects 53 plants 15 feeders	2.5%	22 objects 59 plants 10 feeders
EXXM	0.9%	21 objects 0 plants 8 feeders cement, nonedible ground	1.6%	2 objects 53 plants 15 feeders grassy, edible ground	0.9%	22 objects 59 plants 10 feeders dirt, edible ground

by chimpanzees at San Francisco (the platforms not being considered "vertical climbing area" as defined). Traverse climbing was highest at Sacramento ($G = 178.133$, $p < .0001$) (even though the cage wall area is less than at Oakland) since it was here the primary means of horizontal off ground travel (due to the plaster "rock" wall from ground to 12 feet up, and no girders upon which to walk). Clinging and gymnastics were higher in frequency at Oakland ($G = 656.678$,

$p < .0001$), which had more area but less length of structures enabling them. Sacramento had more device use than Oakland, and more manipulable objects, but San Francisco was highest of all three zoos in device use ($G = 126.747$, $p < .0001$). As explained above, this pattern at San Francisco was due to the popularity of the food dispensers with most of those chimps, and to the use of items in aggressive displays. Explore/examine/manipulate was significantly higher at Oakland Zoo ($G = 17.087$, $p < .0001$), probably due to the high number of plants and the grass and dirt substrate.

Other behaviors may be considered "habitat influenced"; these included all non-passive publicly oriented behavior, feeding and foraging, traveling, and being off exhibit in the night quarters (NVNQ). San Francisco chimpanzees exhibited the greatest occurrence of interactive public oriented behavior, such as aggressive display, begging, and greeting. They were also "NVNQ" significantly more often -- 32.5% of samples, as compared to 3.4% at Sacramento Zoo ($G = 2499.977$, $p < .0001$), even though night quarters access was about the same (at least one door to night houses was open 86% of the time at Sacramento and 85% of the time at San Francisco).

Discussion

It should be noted that the influence of social factors on location preference, feature use, and behavior was not examined in this study. Rearing histories, personalities, dominance struggles, alliances and consortships, presence of infants, and estrous females all may affect those dependent variables, and hence override any habitat influence. Nevertheless, some trends in behavior that may be habitat-related can be gleaned. Chimpanzees at San Francisco and Sacramento zoos spent approximately 61% of their time off ground, despite the disparate amounts of off-ground substrates available at those two zoos. Clearly, the animals preferred to be above ground and would make use of whatever features were available. This pattern was also reflected in some of the specific site preferences, which included platforms, trees, and ledges. Time spent above ground by these captive animals compares well with that of their wild counterparts, 50 - 80% of the day (Goodall, 1968), and was supported by other studies of space use in captive chimps (Traylor-Holzer and Fritz, 1985; Goff et al., 1994).

Along with enabling chimps to exhibit their species-typical nature of being arboreal, off ground substrates at the zoo served an additional function -- that of giving the animals a vantage point to view all the zoo operations: construction, arrival of new animals, and the activities of other animals and zoo employees, who were to them the nearest equivalent of group members or neighbors in the wild. Why chimpanzees at Oakland Zoo were off ground significantly less may be socially or historically pre-determined, or due to the desirability of ground features (softer ground, grassy, more hiding places, etc.). Brent et al., (1991) also saw no significant difference between time spent on and above ground by captive chimpanzees in a playground enclosure at a biomedical research facility in Texas. (In that study, the authors speculate that preoccupation with the grass and above-ground structures that were too small for resting and locomotion may have deterred the chimps being off ground.)

The amount of perching upon a habitat feature at each of the three study zoos was reflected in their respective off ground location totals. Touching of an object was done most often to stabilize the body while perching, thus possibly enabling more perching on structures that alone might be uncomfortable or insecure. A follow up study might look specifically at which objects are favored for perching and touching -- rocks, trees, ropes, nets, beams -- in order to design exhibits with more functionality. Gibson (1990, unpublished) analyzed the use of specific cage features at Sacramento Zoo and found, for example, that logs and trees were used in 50% of samples and cage mesh in 38% of samples.

Perimeter areas were preferred over center areas -- significantly so at Sacramento. If caves are included as "perimeter type" areas, this preference is strengthened, both at Oakland and Sacramento Zoos. Perimeters may provide a sense of security. In addition, traveling paths have been worn into the ground at Oakland Zoo at the exhibit's perimeter, and much time (22.2% of total samples) was spent in locations FP0 and LP0 (cool, shaded, and out of view wall areas) (Table 6). Perimeter preferences have been documented (Traylor-Holzer and Fritz, 1985), and another study showed even higher use of corners (Brent et al., 1991). However, at Sacramento, perimeter use often included use of the off ground ledge, making it difficult to separate perimeter preference from off ground preference. Further statistical analysis is needed.

Climbing and suspending upon habitat features was practically non-existent at all three zoos, which is understandable at San Francisco (which has no cage), but surprising at the other two zoos with plenty of cage ceiling, wall, ropes, and girders. A low travel and movement rate, for whatever reason, may negate the need for these features. Studies in labs have shown the contrary -- that more enriched settings elicited more activity and environmental manipulation, including climbing, swinging, foraging, nest building, and device use during displays (Brent et al., 1991; Clarke et al., 1982). However, in both of those studies, chimpanzees had been newly introduced to those enriched settings, and novelty may have been a factor in their increased activity levels. Wilson (1982) found no correlation between usable surface area and activity in both gorillas and orangutans in European zoos. In addition, some feature uses such as suspending and manipulating may occur more in the context of play behavior. Due to the ages of the group members in this study, this gymnastic and manipulating play was seen only minimally at Oakland Zoo, by the adolescent female. Young chimpanzees in the wild also show higher levels of exploratory behavior than do adults (Goodall, 1986).

Manipulation of food dispensing devices was low at all three zoos, perhaps due to their infrequent availability or short duration. Such devices (peanut puzzle boxes, artificial termite mounds) have been shown to decrease aberrant behaviors, aggression, and idleness (Bloomsmitth et al., 1988; Bloomstrand et al., 1986; Bloomstrand et al., 1987, cited in Maple and Finlay, 1989; Brent and Eichberg, 1991; Maple and Finlay, 1987; Nash, 1982), but should be installed in more than one location in the habitat to reduce aggression from competition. Object manipulation in agonistic contexts was infrequent, but there is still a clear need to provide safe and secure manipulanda for such displays that are likely to become more frequent in captivity. Chimpanzees in the wild drag, throw, and shake objects to accentuate displays (Goodall, 1986). Likewise, male chimps at Sacramento Zoo used ropes in species-typical charging displays while plastic tubs were used at San Francisco Zoo.

The possible correlation between feature-dependent behaviors and amount of environmental variables enabling them (Table 9) deserves rigorous further study. Although those climbing, clinging, and object use behaviors occurred rarely, they were exhibited slightly more often at zoos containing more

features that permitted them. A similar correlation has been documented by Traylor-Holzer and Fritz (1985). In that study at the Primate Foundation of Arizona, chimpanzees utilized upper levels, cage perimeters and partitions, and mesh barriers more often than expected from a random distribution of the animals. These findings will support the argument for providing such structures as jungle gyms, nets, ropes, tires, trees, and boulders. Indeed, upon introduction to their new enclosures in 1986 and 1988, the chimpanzees at Sacramento and Oakland Zoos used structures in ways that were completely unplanned and unanticipated. Exhibit designers and architects never intended the ceiling girders at Oakland Zoo or the narrow ledge where the plaster wall meets the cage mesh at Sacramento Zoo to be structures upon which the chimpanzees would perch. Since the completion of this study, a large uprooted tree and "Tarzan" ropes have been added to the enclosure at Oakland Zoo. Preliminary observations by zoo staff and this author show these items are used extensively for stripping, climbing, jumping and swinging from, and other play gymnastics. Maki and Bloomsmith (1989) showed that an uprooted tree elicited a variety of species-appropriate behaviors. Some environments may encourage innovative behaviors not observed in nature, thus demonstrating behavioral *potentialities* (Erwin and Deni, 1979): if a feature is sturdy, accessible, and interesting enough, it will very likely be used in some way.

Idleness and inactivity was high at all the zoos (occurring in 42.6 - 64.3% of total samples), as compared to the 17 - 32% of the day wild chimpanzees spend resting (Goodall, 1968; Maple & Finlay, 1987). This is less a reflection of the habitat than it is a general condition of captivity. Chimpanzees in the wild spend 8 - 27% of their day traveling, 41 - 60% of it feeding, and the remainder resting or engaged in other social behaviors (Goodall, 1968, 1986; Maple & Finlay, 1987; Wrangham, 1977). With travel and feeding needs removed, there is very little left to do. Although Brent et al., (1991) observed similar rates of inactivity to this study in both impoverished and enriched enclosures, that enriched playground environment elicited more locomotory activity and environmental manipulation (see also Clarke et al., 1982). The presence of the infant at Oakland Zoo increased the activity of all the group members. Larger social groupings, which would in turn lead to dominance challenges, more sexual behavior, and more infants, can be an important factor in decreasing idleness and eliciting more of the potential

behavior repertoire. More complex and enriched environments that include foraging opportunities can increase activity levels. Foods can be provided that require extra time to process, such as artichokes, unhusked corn, and sunflowers. If these foods are hidden and distributed throughout the habitat, foraging and space use can be increased. Placing mirrors in the habitat has been successful in keeping these naturally curious apes occupied for hours (Gibson, P., personal communication, 1991). Several studies of gorillas and orangutans showed increased activity levels in environments with more movable and manipulable objects (Perkins, 1992; Tripp, 1985; Wilson, 1982).

The importance of including hiding places in the habitat is evidenced by the relatively high use of caves at Oakland and Sacramento Zoos (9.9 and 11.9% of total samples, respectively). Instances of hiding behavior were significantly fewer at San Francisco Zoo, perhaps because structures intended for hiding *per se* were not built. Although chimpanzees at San Francisco found places to hide in the moat and within the jungle gym, the night quarters seemed to be their main refuge (see below). Meder (1992) observed that in exhibits with multiple compartments that provided opportunities for withdrawal, gorillas spent less time in the night quarters. Just as wild chimpanzees use trees and foliage to hide behind during disturbances (Reynolds and Reynolds, 1965), hiding places in the zoo exhibit such as caves and boulders provide social, public, and "openness" refuge, escape from inclement weather, and napping places. The cave at Oakland Zoo was occupied daily by the adult female and her infant for the latter's afternoon nap. The use of caves for naps at Sacramento Zoo increased halfway through this study when nighttime access to the exhibit was granted to the chimps. Culverts and partitions have been shown to be effective in increasing social and public distance (Brent et al., 1991; Traylor-Holzer and Fritz, 1985).

Chimpanzees were off exhibit and out of public view in the night quarters in 32.5% of samples at San Francisco Zoo but only in 3.4% of samples at Sacramento Zoo, despite equal availability. The difference may be due to a desire to escape inclement weather: mean temperatures during study hours were 19°C (66°F) at San Francisco and 26°C (79°F) at Sacramento; median weather type was foggy and overcast in San Francisco and sunny in Sacramento. Often the cement grotto at San Francisco would remain damp all day. However, at Sacra-

mento bad weather almost never forced the chimps inside. Summer temperatures often reached 36°C (96°F), and keeper records revealed that only during the coldest, rainiest days of winter would the animals retreat into the night quarters. A more likely explanation is that the night quarters become a hiding place, a refuge from conspecifics and public, when the exhibit does not provide for that need. When animals are off exhibit almost one third of the time, the exhibit is failing in its functions of providing for animal well-being *and* public education. In an extensive study of lowland gorillas in 15 zoos in Europe and the United States, Meder (1992) found that night quarter use by gorillas increased in exhibits that were smaller and too "open". Differing philosophies exist regarding night quarter access during zoo hours. At Oakland Zoo, it is felt that the large exhibit has adequate hiding places and refugia, and enough heterogeneity to provide comfortable microclimates. Closing the night houses also reduces the number of places that a lower ranking chimp could be trapped by a dominant. At the other zoos, it is felt that allowing chimps into the night houses provides refuge, a "canopied" feeling, and helps to build relationships with the keepers. Obviously, this management decision is based heavily on the quality of the exhibit.

The amount and nature of publicly oriented behavior varied significantly between the three zoos, and this may be habitat influenced. Barrier type, viewing access by the public, and habitat perception (aesthetics) by the public can all influence chimpanzee behavior. One would expect that captive chimpanzees would spend a large portion of time watching the zoo public because they are virtually surrounded by and in view of patrons and employees, especially when off ground. Chimps are visual communicators, and keep track of who is where and what they are doing. Human visitors are often a source of enrichment and variety -- they may alleviate boredom. All of this behavior is acceptable until the public becomes a threat, either real or perceived, to the animals. Aggression toward the public can be prompted by the lack of a barrier, too close proximity to the animals, and too large viewing area for the public (resulting in the formation of large crowds of perceived "territory encroachers"). Personal observations by docents and keepers of the chimpanzees at both Oakland and Sacramento Zoos before their moves to the current naturalistic habitats included accounts of feces throwing and spitting when housed in barren

concrete and steel cages only 1 - 2 meters away from the public. Those behaviors are now nonexistent at those zoos. Such displays have diminished at San Francisco Zoo since the chimpanzees were confined to one grotto instead of having access to two, and since the planting of a garden around most of the viewer railing, decreasing public viewing access and proximity. Such gardens also reduced visitor disturbance to gorillas (Meder, 1992). In the absence of an effective barrier, these habitat modifications can also be efficacious in reducing begging behavior and the throwing of items to and from the chimps.

The habitat feature affecting behavior in an unexpectedly profound way was the type of barrier, although this needs further study to confirm. Chimpanzees at San Francisco Zoo, where there is effectively no space barrier around the exhibit, react negatively to taunting and yelling by the provoking public. A typical response was an aggressive display accompanied by the throwing of feces, burlap sacks, or sticks. A glass barrier reduces the transmission of sound into the habitat and stops the passing of items into and out of it, which may transfer infection between chimpanzees and the public. Begging by and feeding of the animals is also prevented. Such negative publicly-oriented behavior ceased at Sacramento Zoo when the chimpanzees were transferred to their glass enclosed exhibit in 1986. Although Maple (1979) has suggested that a glass barrier reduces public distance and may result in chimpanzees kicking and hitting the glass at the public, ironically, three of the four chimps at Sacramento now spend a great deal of time sitting at the glass, engaging in *positive* interactions with the public (such as through-the-glass hand touching and kissing, and hide and seek games). Such positive behavior has also been documented by Meder (1992) in captive gorillas in glass enclosures, who also observed increased public watching and displaying with moat and steel bar barriers. Similarly, negative public interactions ceased at Oakland Zoo when chimps were transferred to their current cage mesh and glass walled enclosure in 1988. Although sound and scent can still be transmitted through cage mesh, if the mesh size is small enough, food and other objects cannot. Mesh barriers have the added benefit of supplying additional climbing surfaces. Since it is often difficult to encourage appropriate behavior by the zoo public, the most effective way of reducing their disturbance may be to erect glass barriers, perhaps with mesh above.

During this study, it occurred to this author that the zoo habitat may also affect visitor behavior, which could in turn affect chimpanzee behavior. Chimpanzees at Sacramento Zoo were idle more and publicly oriented less than those at San Francisco, yet the public did not try to incite them or elicit a response from them as was so often the case at San Francisco. Is it the habitat? Is it the beauty and serenity created by the bamboo, the waterfall, and the canopy that make people just stand and watch? Perhaps an enriched and complex environment affects the behavior of both primates in a sort of positive feedback loop:

A similar "reverent" behavior was shown by the zoo visitors at Oakland Zoo. It has been suggested and demonstrated that visitor behavior is correlated with architectural characteristics of the exhibits, that poor exhibits may reinforce attitudes of human superiority and indifference, and that visitors preferred exhibits that simulate an animal's home region (Bitgood et al., 1988; Maple, 1983; Shettel-Neuber, 1988). Coe (1985) has suggested zoo designs that may predispose visitors to learn from and enjoy what they experience, and this author is very interested in pursuing the question of exhibit design and visitor behavior.

Chimpanzees are somewhat arboreal, and therefore need off ground substrates. They are brachiators, and therefore need clinging and suspensory structures. They are tool makers and users in food getting, drum and branch users in displaying, and nest builders – and so need food dispensing devices that require a tool, and other browse and manipulables. Chimps are travelers, and so need space. Females are somewhat solitary in the wild, and need caves and hiding places to claim as core areas. Chimpanzees are rainforest dwellers, and therefore need cover and shade. Their captive environments must be more than just landscaped simulations. They need not even be pleasing to the human eye. But the features within must function as counterparts to habitat components in the wild. Species-typical behaviors may not magically emerge with the introduction of trees and rocks, unless those introductions are done based on

data from studies similar to this one. Post-addition and post-occupancy evaluations in particular (Maple and Finlay, 1986) are needed in many more zoos, in "fine tuning" an existing habitat or designing a new one that will effectively provide for all the animal's needs.

Conclusions

1. Chimpanzees at San Francisco and Sacramento Zoos, but not Oakland Zoo, are off ground significantly more than on ground, although the number and area of off ground substrates is highest at Oakland and lowest at San Francisco.
2. Perimeters (including caves) were favored over center areas at Oakland and Sacramento Zoos. Hiding behavior was significant at Oakland and Sacramento Zoos, indicating the need to plan and provide for such secure features in zoo design.
3. The feature uses of leaning, suspending, climbing, and manipulating were low at all zoos, and perching was high, despite varying amounts of structures at the three zoos enabling those uses.
4. Device use is significantly higher at San Francisco Zoo, where more food enrichment devices are provided and more manipulable objects are available for use in displays.
5. Chimpanzees are significantly less idle at Oakland Zoo, but this is most likely a socially influenced phenomenon, not a habitat influenced one.
6. Chimpanzees are publicly oriented significantly more at San Francisco Zoo, both passively and active/antagonistically, and they are off exhibit in the night quarters significantly more. Both behaviors may be due to the lack of an effective barrier around and appropriate hiding places within the exhibit.

References

- Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour* 49: 227-265.
- Bitgood, S., D. Patterson, & A. Benefield. 1988. Exhibit design and visitor behavior: empirical relationships. *Environment and Behavior* 20: 474-491.
- Bloomsmith, M. A., P. L. Alford, & T. L. Maple. 1988. Successful feeding enrichment for captive chimpanzees. *American Journal of Primatology* 16: 155-164.
- Bloomstrand, M., K. Riddle, P. Alford, & T. L. Maple. 1986. Objective evaluation of a behavioral enrichment device for captive chimpanzees (*Pan troglodytes*). *Zoo Biology* 5: 293-300.
- Brent, L. & J. W. Eichberg. 1991. Primate puzzleboard: a simple environmental enrichment device for captive chimpanzees. *Zoo Biology* 10: 353-360.
- Brent, L., D. R. Lee, & J. W. Eichberg. 1991. Evaluation of a chimpanzee enrichment enclosure. *J. Med. Primatol.* 20: 29-34.
- Clarke, A. S., C. J. Juno, & T. L. Maple. 1982. Behavioral effects of a change in the physical environment: a pilot study of captive chimpanzees. *Zoo Biology* 1: 371-380.
- Coe, J. C. 1985. Design and perception: making the zoo experience real. *Zoo Biology* 4: 197-208.
- Eichberg, J. W., D. R. Lee, T. M. Butler, J. Kelley, & L. Brent. 1991. Construction of playgrounds for chimpanzees in biomedical research. *J. Med. Primatol.* 20: 12-16.
- Erwin, J. & R. Deni. 1979. Strangers in a strange land: abnormal behaviors or abnormal environments? Pages 1-28 in *Captivity and behavior*. J. Erwin, T. L. Maple, & G. Mitchell, eds. New York: Van Nostrand Reinhold Co.
- Goff, C., S. M. Howell, J. Fritz, & B. Nankivell. 1994. Space use and proximity of captive chimpanzee (*Pan troglodytes*) mother/offspring pairs. *Zoo Biology* 13: 61-68.

- Goodall, J. 1968. The behavior of free-living chimpanzees in the Gombe stream area. *Anim. Beh. Monogr.* 1: 161-311.
- Goodall, J. 1984. Gombe Stream ethogram of chimpanzee behaviors (not published). 44pp.
- Goodall, J. 1986. The chimpanzees of Gombe: patterns of behavior. Cambridge, MA: The Belknap Press of Harvard University Press. 673 pp.
- Jane Goodall Institute. 1991. The ChimpanZoo observers guide. Tucson, AZ: Jane Goodall Institute. 94 pp.
- Maki, S. & M. A. Bloomsmit. 1989. Uprooted trees facilitate the psychological well-being of captive chimpanzees. *Zoo Biology* 8: 79-87.
- Maple, T. L. 1979. Great apes in captivity: the good, the bad, and the ugly. Pages 239-272 in Captivity and behavior. J. Erwin, T. L. Maple, & G. Mitchell, eds. New York: Van Nostrand Reinhold Co.
- Maple, T. L. 1983. Environmental psychology and great ape reproduction. *Int. J. Stud. Anim. Prob.* 4: 295-299.
- Maple, T. L. & T. W. Finlay. 1986. Evaluating the environments of captive non-human primates. Pages 479-488 in Primates: the road to self-sustaining populations. K. Benirschke, ed. New York: Springer Verlag.
- Maple, T. L. & T. W. Finlay. 1987. Post-occupancy evaluation in the zoo. *Applied Animal Behaviour Science* 18: 5-18.
- Maple, T. L. & T. W. Finlay. 1989. Applied primatology in the modern zoo. *Zoo Biology Suppl.* 1: 101-116.
- Meder, A. 1992. Effects of the environment on the behaviour of lowland gorillas in zoos. *Primate Report* 32: 167-183.
- Nash, V. J. 1982. Tool use by captive chimpanzees at an artificial termite mound. *Zoo Biology* 1: 211-221.
- Perkins, L. A. 1992. Variables that influence the activity of captive orangutans. *Zoo Biology* 11: 177-186.

- Reynolds, V. & F. Reynolds. 1965. The natural environment and behavior of chimpanzees *Pan troglodytes schweinfurthi* and suggestions for their care in zoos. *Int. Zoo Yearbk.* 5: 141-144.
- Shettel-Neuber, J. 1988. Second- and third- generation zoo exhibits: a comparison of visitor, staff, and animal responses. *Environment and Behavior* 20: 452-473.
- Traylor-Holzer, K. and P. Fritz. 1985. Utilization of space by adult and juvenile groups of captive chimpanzees (*Pan troglodytes*). *Zoo Biology* 4: 115-127.
- Tripp, J. K. 1985. Increasing activity in captive orangutans: provision of manipulable and edible materials. *Zoo Biology* 4: 225-234.
- Wilson, S. F. 1982. Environmental influences on the activity of captive apes. *Zoo Biology* 1: 201-209.
- Wrangham, R. W. 1977. Feeding behavior of chimpanzees in Gombe National Park, Tanzania. Pages 503-538 in *Primate ecology*. T. H. Clutton-Brock, ed. London: Academic Press.
- Yerkes, R. M. 1925. *Almost human*. New York: Century. 278 pp.

Appendix

ABOUT CHIMPANZOO

ChimpanZoo is a research program designed in 1984 by The Jane Goodall Institute for Wildlife Research, Education and Conservation to study the behavior of chimpanzees in zoos. It is a cooperative effort by zoos, academic institutions, and the Institute to collect behavioral data in zoos throughout the United States. Its goals are to increase the public's understanding and awareness of primates and particularly chimpanzees; to provide information about the behavior of zoo chimpanzees that will assist the zoos in their efforts to improve habitats and conditions for their chimpanzees; to promote knowledge about effective techniques to enrich the psychological environment of chimpanzees; and to provide a constantly growing data base of behavioral observations that will contribute to the body of knowledge on chimpanzee behavior. There are currently sixteen participating zoos collecting data on approximately 130 chimpanzees. An annual national conference is held for the presentation of papers, posters, and videos, and for valuable in-depth discussions between keepers, students, and professors from the various study sites.

For more information about ChimpanZoo, contact Dr. Virginia Landau, JGI ChimpanZoo Director, University of Arizona, 800 E. University Blvd., Rm 308, Tucson, AZ 85721.

SAMPLE DATA COLLECTION SHEET

[illegible]

FEATURE USE DEFINITIONS

Touching -- Using a part of the body (usually hands or feet) to make contact with a structure other than the one supporting the chimp. Includes an idle sort of contact, as well as holding onto something to stabilize oneself.

Leaning Against -- While sitting or standing on the ground or other substrate, the chimp leans or props its body against a feature for support.

Suspending From -- Hanging by 1, 2, 3, or 4 limbs from a structure that is more or less parallel with the ground. May involve horizontal or diagonal movement within the habitat.

Climbing Upon -- A vertical ascent or descent, using all 4 limbs, upon a structure that is more or less perpendicular with the ground. Includes clinging with 4 limbs to a vertical structure.

Manipulating Of -- Similar to touching, but more purposeful. Perhaps best defined by example: procuring food from a peanut dispenser, termite mound, raisin board, or food barrel; swinging or shaking a net, chain, or rope for play, display, or attention getting purpose; removing or stripping permanent plant material; any use of "toys" large enough to be considered permanent fixtures (i.e. cannot be thrown from habitat) such as tires, garbage cans, barrels, etc.

Perching Upon -- Includes reclining, sitting, standing, and walking upon any structure parallel to and off the ground.

Hiding Behind -- Using a feature to partially or entirely hide or seek social, public, or "openness" refuge within or behind. Areas may include caves, moats, perimeter areas, crawl tubes, vegetation, behind boulders, or any such area where a chimp is partially obscured from view. (Often the immediate social behavioral events will reveal if a chimp is hiding or seeking "time out".)

BEHAVIOR CATEGORIES

ABERRANT -- behaviors generally not seen in wild chimpanzees. May result from hand rearing, stress, and captivity. Includes ABMV, all ABOR, FECA, and HPSF, in affiliative and solitary contexts.

AFFINITIVE -- Social, non-agonistic, non-aberrant, and non-parenting behaviors. Includes Affinitive APES, APRO, ARMS, all AVOD, BEGH, BEGM, BPSW, BPST, BPWR, CHAS, CLNG, all CORT, DRNK, DVUS, EMBR, EXXM, GRAB, GRMT, GROT, GRRC, GRSF, GYMN, HNCH, INSP, KISS, MBAT, IDST, IDRC, RECL, SITT, TRCL, VRCL, all PLAY, all PSNT, QDST, QDWR, REAS, SCSL, TAKE, TBOD, TFAC, TOTH, all VOCA, WTCH; Submissive TOTH, PSNT, GROT, all AVOD, ARMS, APRO, APES.

AGONISTIC -- aggressive behavior toward another chimpanzee or the public, prompted by anger or frustration, or to assert dominance or territory. Includes Affinitive ATDS; Agonistic all AGRD, APRO, ARMT, BITE, BPST, BPSW, BPWR, CHAS, CLNG, DVUS, GRAB, GYMN, HNCH, HOLD, QDST, QDWR, SLAP, THRO, TRCL, all VOCA, VRCL, WTCH; Public Oriented all AGRD, ARMT, BPSW, BPWR, DVUS, HNCH, THRO; Solitary all AGRD, BPSW, THRO.

DEVICE/OBJECT USE -- purposeful use of a permanent or temporary object. Includes Affinitive and Solitary DVUS, EXXM, FORG, HOLD; Agonistic DVUS, HOLD; Public Oriented DVUS.

FOOD RELATED -- involves the procuring, processing, and consumption of food and water. Includes Affinitive and Solitary DRNK, FOOD, FORG.

IDLE/INACTIVE -- the body is not moving. Includes Affinitive and Solitary IDST, IDRC.

PARENTING -- any adult caring for any infant. Includes Affinitive ALOP, CARD, PROT; Mothering/Alloparenting APRO, ARMS, CARD, EMBR, GRMT, GROT, GRRC, NURS, all PLAY, PROT, WTCH.

BEHAVIOR CATEGORIES, cont'd.

PUBLICLY ORIENTED -- passive or active behavior obviously directed at the zoo patrons or employees. Includes Public Oriented all AGRD, ARMT, BEGH, BEGM, BPST, BPSW, BPWR, DVUS, GYMN, HNCH, SLGR, THRO, all VOCA, WTCH.

SOLITARY -- non-social (more than arm's length from another), non-aberrant, non-agonistic behavior. Includes Solitary BPST, BPWR, CLNG, GRSF, GYMN, HNCH, MBAT, IDST, IDRC, QDST, QDWR, RECL, SITT, TRCL, VRCL, SCSL, TBOD, TFAC, all VOCA, HOLD, DRNK, FOOD, FORG, DVUS, EXXM.

TRAVEL/MOVEMENT -- non-agonistic locomotion in the habitat. Includes Affinitive BPWR, CHAS, GYMN, TRCL, VRCL, QDWR; Solitary BPWR, GYMN, QDWR, TRCL, VRCL, BPWR, GYMN.