

Variation in Stereotypic Behavior Related to Restraint in Circus Elephants

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The purpose of this study was to determine the effect of penning and chaining on circus elephant behavior. The behaviors of 10 Asian elephants (*Elephas maximus*) and three African elephants (*Loxodonta africana*) were videotaped for at least 24 hours at each of six performance locations. At four of these locations, the elephants were restrained in electric-wire pens on turf and at two locations the elephants were restrained via leg chains on macadam. Instantaneous scan sampling at 5-minute intervals during each observation period was conducted to determine the frequency of occurrence of seven behavior categories: aggression, comfort, ingestion, locomotion, resting, social, and stereotypy. Stereotypies and social interaction ($P < 0.0008$) were more likely with chained restraint; comfort, ingestion, and locomotion activities were less likely ($P < 0.0037$) with chained restraint, whereas aggression and resting activities were not affected by type of restraint ($P > 0.6254$). Variation in stereotypic activity was related to age ($P = 0.0001$), with younger elephants more likely to show stereotypic activity than older elephants. Zoo Biol 19:209–221, 2000. © 2000 Wiley-Liss, Inc.

Key words: stereotypies; management; *Loxodonta africana*; *Elephas maximus*; penning; chaining

INTRODUCTION

Historically, elephants in captivity have been restrained by chaining [Wiedemayer and Tanner, 1995]. As a result of chaining, species-typical behaviors, such as foraging for food, social interactions, play behavior, and locomotion are greatly re-

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stricted. This inability to perform species-typical behaviors may contribute to the development of stereotypies in elephants [Wiedenmayer and Tanner, 1995].

Stereotypies can be defined as unvarying, repetitive behaviors that have no obvious goal or function [Fox, 1965; Hutt and Hutt, 1965]. Stereotypies have been associated with sub-optimal housing or management systems [Mason, 1991] and are thought to develop due to the inability of captive animals to control their environment [Carlstead, 1996] or choose a desired behavior [Mason, 1991]. These thwarted behaviors, normally available to animals in the wild, may include foraging, escape, and other species-typical behaviors such as social interaction [Carlstead, 1996]. Stereotypies tend to increase in frequency in caged mink before being fed [Mason, 1993]; in elephants before being fed, being watered, and performing [Friend, 1999]; in dingos separated from the rest of their pack [Fox, 1968]; and in stallions prevented from approaching mares in estrus [Broom and Kennedy, 1993].

To understand better stereotypic behaviors of elephants in captivity, species-typical behaviors in free-ranging elephants should be considered. In the wild, elephant family herds are comprised of female elephants related to the matriarch, usually sisters or daughters, and their offspring [Moss, 1983]. The matriarch, usually the oldest and largest female, influences the day-to-day routine of the herd [Moss, 1983; McKnight, 1995]. Typically, wild elephants will spend between 16 and 20 hours a day feeding [Vancuylenberg, 1977; McKnight, 1995; Vinod and Cheeran, 1997], with peaks in the morning, afternoon, and around midnight [Eltringham, 1982]. Depending on availability of water, wild elephants will drink once per day [Eltringham, 1982]. Free-ranging elephants will sleep 4 to 5 hours a day, either in a recumbent or standing position, usually between 0200 and 0700 hours [Wyatt and Eltringham, 1974; McKnight, 1995] and again during the hottest part of the day [Eltringham, 1982].

Species-typical behaviors also include comfort and social activities. Comfort behaviors include bathing, wallowing, and grooming. Social activities include affiliative and conflict behaviors. Elephants are extremely social and touch each other frequently. The most common affiliative behavior is the trunk-to-mouth greeting, in which an elephant will put its trunk tip into another elephant's mouth [Adams and Berg, 1980; Garai, 1991]. Affiliative behaviors also include play activities, such as mock fighting or chasing. Conflict behaviors, such as trunk slapping or tusk pushing, usually involve older elephants disciplining the younger ones. Actual fighting between adults rarely occurs [Eltringham, 1982].

Social groupings may influence species-typical behaviors in captivity. These groups generally consist of unrelated females, often both Asian and African, brought together from different locations. Strong social bonds can be formed [Garai, 1991] depending on the length and type of relationship. For example, stable groups may become volatile by the introduction of a new individual or re-introduction of a group member after some time apart [Tim Frisco, personal communication], or change spontaneously.

It is now a more common practice for zoo elephants to be left unchained unless chaining is necessary for husbandry practices, e.g., to help manage aggression between members of captive social groups. In both the Zurich Zoo and Zoo Atlanta, there was a decrease in the occurrence of stereotypies in elephants when they were left unchained [Wiedenmayer and Tanner, 1995; Brockett et al., 1999].

Routine chaining of circus elephants is also becoming less common. A study of four European circuses indicated that, although 19 of 29 elephants displayed stereo-

types both when chained and penned, stereotypies occurred less frequently when the elephants were penned [Schmid, 1995]. When a North American circus switched from chained restraint (1996) to penned restraint (1998) [Friend and Parker, 1999], stereotypic activity in nine older female elephants (27–52 years) was reduced an average of 57%. Other factors associated with reduced stereotypic activity included older age and food availability [Friend and Parker, 1999]. The probability of species-typical activities (e.g., standing, lying, eating) varied substantially among individuals during early morning hours, when not influenced by human activities [Friend and Parker, 1999]. During daylight hours, individuals differed in the time they were removed from restraint for circus performances and other work routines [Friend and Parker, 1999], which was negatively correlated with stereotypic behavior ($r = -0.71$, $P = 0.031$, $N = 9$).

The purpose of this study was to examine the stereotypic activity of elephants in the circus studied by Friend and Parker [1999] during the year of transition (1997) when both chained and penned restraint were used. Additionally, this study examined the variation in behavior within a treatment, between seasons, and within time periods across locations.

METHODS

Subjects and Husbandry

Nine female Asian, one male Asian, and three female African circus elephants were observed for this study (Table 1). The elephants ranged in age from 6 to 51 years, and each belonged to a smaller social group consisting of one to four elephants arranged by the circus depending on compatibility. To examine whether behaviors varied with age, three age groups were established, with at least three subjects in each age group. The age groups were 1) younger than 20 years old ($n = 3$), 2) 20–40 years old ($n = 7$), and 3) older than 40 years old ($n = 3$).

During this study, daily management practices were fairly consistent. The circus stayed at each performance location for 2 days. Once at a location, the elephants

TABLE 1. Biographical information of elephants observed in this study

Elephant ^a	Species ^b	Sex	Born	Age group ^c	Year acquired by circus
A	E	F	1947	C	1950
B	E	F	1946	C	1973
C	E	F	1952	C	1954
D	E	F	1970	B	1974
E	E	F	1970	B	1974 ^d
F	E	F	1970	B	1974 ^d
G	E	F	1968	B	1973
H	E	F	1969	B	1974 ^d
I	E	F	1970	B	1995
J	L	F	1982	A	1991 ^d
K	L	F	1971	B	1974
L	L	F	1982	A	1991
M	E	M	1991	A	1995

^aElephants arranged according to social groups.

^bE, *Elephas maximus*; L, *Loxodonta africana*.

^cA, younger than 20 years old; B, 20–40 years old; C, older than 40.

^dYear acquired uncertain.

were placed in pens or chained to picket lines, usually between 0900 and 1000 hours. At each location, the elephants were kept chained or penned unless performing some form of work (e.g., giving rides, performing in the show) or occupied in a daily management activity (e.g., baths, foot care). The elephants were given water three times a day, grain once a day, and hay from 8 to 10 times a day. At each location, the elephants had almost continual access to hay. A more detailed description of daily management activities can be found in Friend [1999].

Experimental Treatments

Data were collected at six locations, two in Texas and four in California, from April to June 1997 (Table 2). At two of the locations, the elephants were chained on macadam and at four other locations they were penned on turf. The determination of whether the elephants would be chained or penned was based on the surface at the performance site. At the time of this study, the pens were made by securing posts into the substrate on which the elephant compound was set up. On surfaces that were too hard, such as macadam, where the posts could not be driven far enough into the surface so as to be secure, the elephants were chained. Otherwise, the elephants were penned. This was a practical decision made by the circus based on substrate and not open to manipulation for this research. Two treatments were used in this study, but regardless of treatment, the groupings of the subjects when penned were maintained throughout the study.

Treatment 1

The elephants were chained to a picket line, which consisted of two parallel cables attached to two tractor trailers with 25–30 m between the trailers and 3 m between the cables (Fig. 1). Two picket lines, separated by a tractor-trailer, were used, with 8 to 10 elephants chained in a row on each. The elephants were chained by one front foot and opposite back foot to the cables, which allowed them to move roughly 1 m forward or backward with little sideways movement. Members of each social group were chained adjacent to each other. All picket line members had olfactory and auditory contact and limited visual contact with the other elephants on that picket line. Full visual and tactile contact was only possible between adjacent elephants.

TABLE 2. Variation in environmental variables across locations of circus performance^a

Restraint type	Season ^b	Max temp (°F)	Min temp (°F)	Precipitation (inches)	Weather conditions
Chained on macadam					
Ft. Hood, TX	Spring	77.0	55.4	1.06	Cloudy with steady rain
Palmdale, CA	Summer	87.8	53.6	0.00	Sunny and hot
Penned on turf					
Austin, TX	Spring	64.4	53.6	0.08	Cloudy with intermittent rain
Moorpark, CA	Summer	93.0	77.0	0.00	Sunny and hot
Goleta, CA	Summer	76.0	59.0	0.00	Sunny and cool
Santa Maria, CA	Summer	75.2	57.2	0.00	Sunny and cool

^aMax temp, min temp, and precipitation information from the NCDC, 1998; weather conditions are from personal observation.

^bSpring was March–April; summer was May–June.

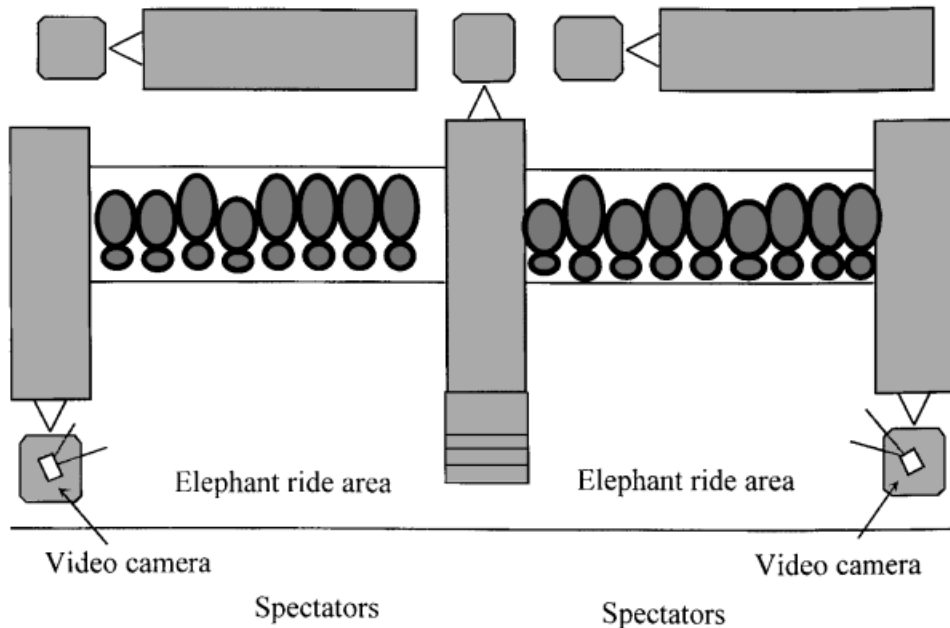


Fig. 1. Elephant area when chained. Elephants and other features are not to scale.

Treatment 2

The elephants were kept in the same general area as when they were chained. However, each area was divided into four or five pens, with each pen holding a separate social group of one to four elephants (Fig. 2). One or two elephants were kept in pens measuring approximately 80 m² and three or four elephants were kept in pens measuring approximately 150 m². A conventional livestock fence charger was used to electrify two parallel strands of 2-cm wide electric fence ribbon. The ribbon ran approximately 0.5 and 1.35 m above the ground and were supported by plastic insulators on metal "T" posts. Penned restraint allowed full contact among all elephants within a group, partial tactile contact between adjacent groups, and no tactile contact between non-adjacent groups. As when chained, elephants located on opposite sides of the center tractor-trailer did not have visual or tactile contact with each other.

Data Collection and Handling

A separate camera and video recorder videotaped members of each picket line or group of pens. Each camera was mounted on a tractor-trailer adjacent to the elephant area. Nighttime lighting was provided by four 150-W halogen flood lamps mounted on 3-m poles placed in front of the picket line or pens. Data collection consisted of VCR time-lapse video taping using two Panasonic WV-BP312 CCTV cameras, each with a WV-LA 2.8-mm wide angle auto iris lens and a Panasonic VHS AG-1070 DC video recorder recording at 2.23 frames/s.

The elephants were observed for a total of 48 hours when chained and 94.5 hours when penned. Instantaneous sampling of each elephant's behavior was made at 5-minute intervals from the video recordings [Altmann, 1974; Martin and Bateson, 1993]. Each

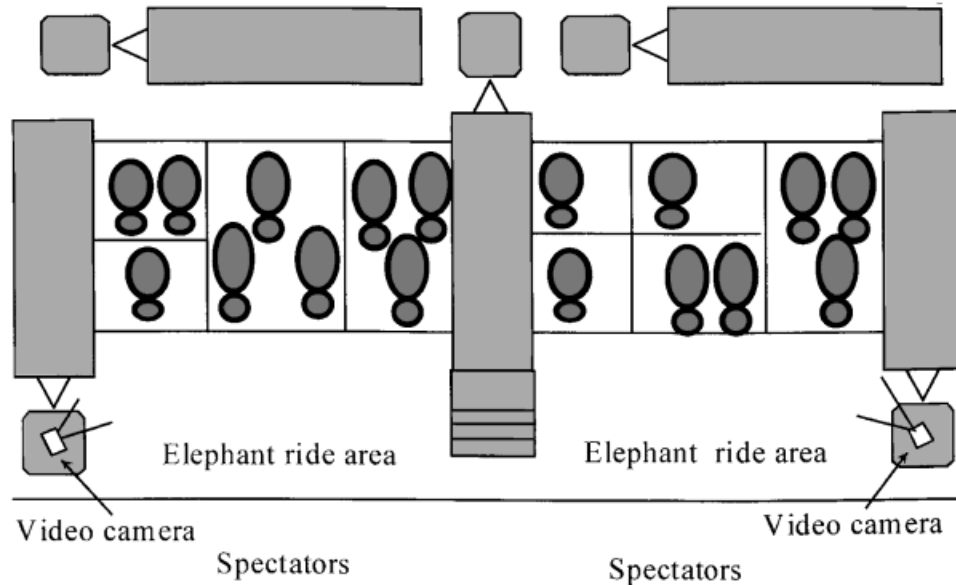


Fig. 2. Elephant area when penned. Elephants and other features are not to scale.

behavior observed was allocated to one of seven activity states. These were aggression, comfort, ingestion, locomotion, resting, social, and stereotypies (Table 3).

The percentage of observations performing each activity was determined for each elephant at each of the six locations. To determine the effect of treatment, season, and age on behavior, a factorial analysis of variance, using PROC GLM in SAS [SAS, 1996], was conducted, as appropriate for unequal sample sizes. In these analyses, treatment, season, and age were the main effects and frequency of behavior was the dependent variable. To determine the effect of location on elephant behavior, a factorial analysis of variance on the same data were performed with treatment, location, and age as the main effects.

If significant main effects were found ($\alpha = 0.05$), a Duncan's multiple-range test was conducted to determine where the significant differences occurred. When significant interactions between main effects were found, a least-squares means test was conducted to determine where the significant differences occurred.

To determine the effect of time of day on behavior, a log-linear analysis, using PROC CATMOD in SAS [SAS, 1996], was conducted for each elephant. The day was divided into four periods: morning (0300–0859), midday (0900–1459), evening (1500–2059), and night (2100–0259) because husbandry activities were usually started by 0900. Individuals were compared within a time period, but no comparisons were made between time periods. The log-linear analyses compared the actual number of displays of a given behavior with what was expected by chance. When significant differences were found, binomial z-scores [Bakeman and Gottman, 1986] were used to determine whether the actual number was significantly more or less than what was expected by chance.

Between-observer reliability was measured to determine the accuracy of behavior definitions used within each category. A videotape was picked at random and two observers independently measured each elephant's behavior at 5-minute inter-

TABLE 3. Observed behaviors of circus elephants grouped by category

Category	Behavior	Definition
Aggression	Bumping	Forceful pressure with the hip against another elephant
	Kicking	Forward or sideways thrusting of the foot at another elephant
	Threatening	Standing with ears spread and head held high
Comfort	Chain pulling	Pulling on the foot chain with trunk or foot
	Pawing	Pawing the ground before laying down
	Rubbing	Rubbing against an object
	Scratching	Scratching the body with trunk or foot
	Searching	Searching the ground with the trunk
	Spraying	Spraying water, dirt, or food on the body with the trunk
	Trunk up	Trunk curved upward
Ingestion	Eating	Picking food up or other material (pick up more than hay or grain) with the trunk, placing into the mouth, and swallowing
	Drinking	Picking water up with the trunk, placing into the mouth, and swallowing
	Foraging	Using the trunk and/or foot to search the ground for food
Locomotion	Moving around	Any walking or stepping to the side in a non-stereotypic pattern when not performing any other behavior
Resting	Laying	Lateral recumbency
	Standing	Upright on all four legs, trunk flaccid; not performing any other identified behavior
Social	Leaning	Leaning on another elephant
	Standing	Standing over another elephant
	Touching	Touching another elephant in a non-aggressive manner with trunk
	Twining trunks	Gentle overlapping of trunk with another elephant
Stereotypies	Weaving	Side-to-side or back-and-forth repetitive swaying of the body
	Headbobbing	Moving head up and down in a repetitive manner
	Trunk tossing	Vigorous swaying of trunk from side to side
	Pen pacing	Walking around in an unvarying, repetitive pattern

vals for the entire tape using the pre-defined ethogram (Table 3). An index of concordance, comparing the total number of agreements (A) and disagreements (D), was performed using the formula $I = A/(A + D)$ [Martin and Bateson, 1993].

Within-observer reliability was measured to determine whether there was any “observer drift” during the duration of the study. A videotape was picked at random, and on two separate occasions the same observer measured each elephant’s behavior at 5-minute intervals for the entire tape using the pre-defined ethogram (Table 3). An index of concordance was then performed using the formula $I = A/(A + D)$ [Martin and Bateson, 1993].

A 94% agreement was found for between-observer reliability and a 96% agreement was found for within-observer reliability. These would indicate that the definitions used for each behavior within a category (Table 3) were robust and that there was minimal observer drift.

RESULTS

There were not enough occurrences of aggression (0.1% of observations when chained, 0.1% when penned) to perform statistics.

The elephants engaged in more comfort ($P = 0.0037$), ingestion ($P = 0.0001$), and locomotion ($P = 0.0001$) activities and fewer social interactions ($P = 0.0008$) and stereotypies ($P = 0.0001$) when penned than when chained (Fig. 3). There were no treatment effects on resting activities ($P = 0.6254$).

Age (Fig. 4) had a significant effect on comfort ($P = 0.0256$), ingestion ($P = 0.0001$), locomotion ($P = 0.0472$), resting ($P = 0.0001$), and stereotypies ($P = 0.0001$). There was no effect of age on social activity ($P = 0.2323$). The oldest group engaged in more comfort activities than the youngest group. The two older groups ingested more than the youngest group. The oldest group rested more, moved around less, and displayed fewer stereotypies than both younger groups, with the youngest group resting the least and moving around and displaying stereotypies the most.

There was a significant interaction between treatment and age (Table 4) for the categories of locomotion, resting, social, and stereotypies. The two younger groups moved around more when penned than when chained, with the youngest group moving around the most. The youngest group rested more when penned than when chained. Also, when chained, the youngest elephants rested the least and the oldest elephants the most. The two older groups displayed more social activities when chained than when penned. Each age group displayed more stereotypies when chained than when penned, with occurrences decreasing by age group for both treatments. There was no treatment and age interaction for comfort or ingestion activities.

No season effects ($P > 0.1518$) on behavior were found, and, although there were location effects, these agreed with significant effects owing to treatment. For example, the elephants spent less time performing ingestion-related behaviors at both chained locations than at each of the four penned locations [Gruber, 1999]. Time of day was

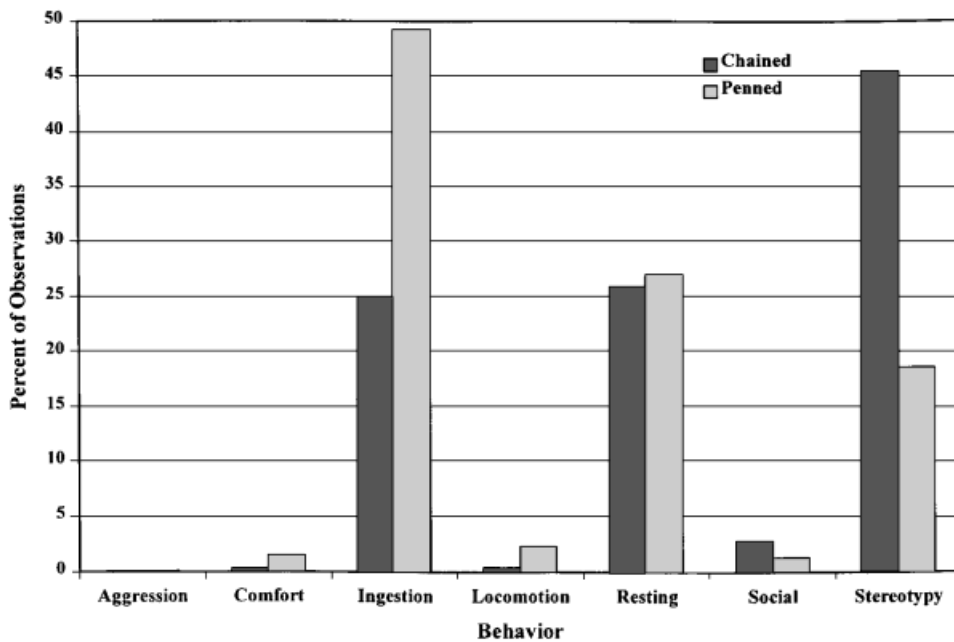


Fig. 3. Effect of treatment on behavior.

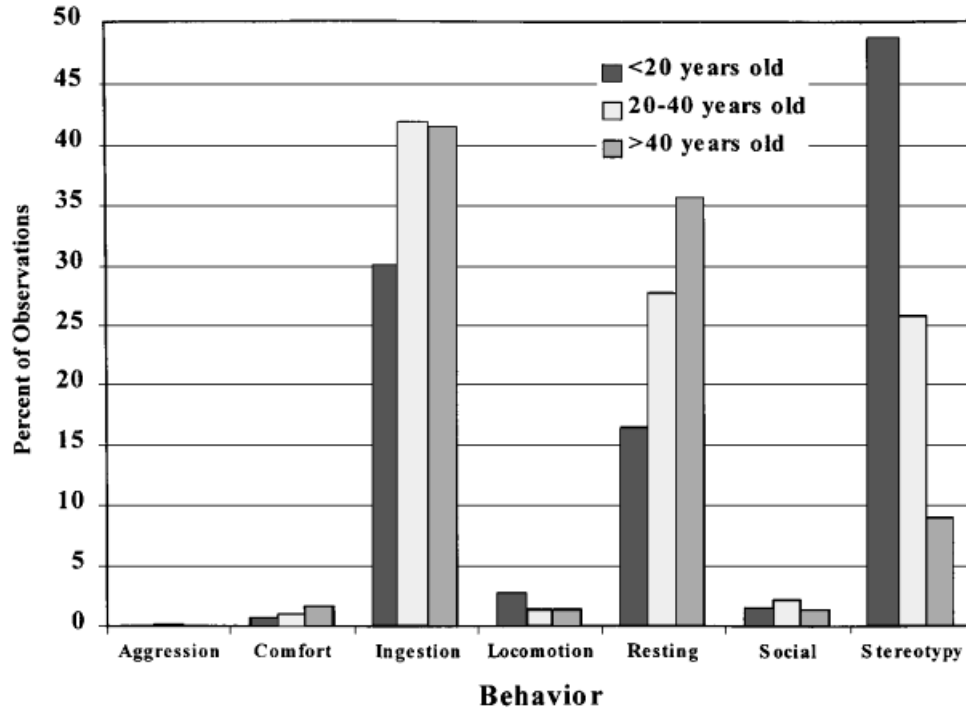


Fig. 4. Effect of age on behavior.

significant ($z = 3.0$) for stereotypies during the 1500 to 2100-hour period. Eleven of the 13 elephants displayed more stereotypies during this time period than expected [Gruber, 1999].

DISCUSSION

Alternatives to chained restraint have been associated with decreased stereotypies in several studies. In the present study, 13 elephants from one U.S. circus were studied during the year of transition from chained restraint to penned restraint

TABLE 4. Effect of treatment and age interaction on elephant behavior^a

	Chained ^b			Penned ^b			P-value
	A ^c	B ^c	C ^c	A	B	C	
Aggression	0.0	0.1	0.1	0.0	0.1	0.0	NA
Comfort	0.1	0.3	0.6	1.2	1.4	2.1	NA
Ingestion	6.5 ^{a,b,c}	28.6 ^{a,d}	36.6 ^{b,c}	42.3 ^{c,f}	48.4 ^{d,g}	58.9 ^{e,f,g}	0.0638
Locomotion	0.2 ^h	0.5 ⁱ	0.5 ^j	4.0 ^{h,k,l}	1.9 ^{j,k}	1.7 ^{j,l}	0.0004
Resting	4.7 ^{m,n,o}	29.3 ^{m,p}	41.7 ^{n,p,q}	22.8 ^{o,r}	26.8 ^s	32.3 ^{q,r,s}	0.0001
Social	0.7 ^u	4.0 ^{t,v}	2.6 ^{u,w}	1.9	1.3 ^v	0.6 ^w	0.0019
Stereotypy	88.0 ^{x,y,z}	37.2 ^{x,aa,bb}	17.9 ^{y,aa,cc}	27.7 ^{z,dd}	20.0 ^{bb,ee}	4.3 ^{cc,dd,ee}	0.0079

^aWithin a row, means with the same superscript differ ($P < 0.05$). Comparisons were made only between treatments within an age group or between age groups within a treatment.

^bPercentage of observations.

^cAge groups: A, <20 years old; B, 20–40 years old; C, >40 years old.

(1997). Each of the elephants displayed stereotypies in both management systems and, although the display was lower when the elephants were penned (a decrease of 59%), stereotypies still accounted for nearly 20% of the behaviors displayed. Similar findings have been reported in two studies using different methods and (or) husbandry procedures. Friend and Parker [1999] studied elephants from the same circus as the present study the year before and the year after the transition year. They found that stereotypic behaviors decreased an average of 57% when the elephants were penned compared to when they were chained. Schmid [1995] studied four European circuses in which the elephants were both chained and penned during the same day. Schmid [1995] found the occurrence of stereotypies was nearly absent when the elephants were penned and 10 of 29 elephants did not display any stereotypies when penned. One possible explanation for the difference between the Schmid study and the present study was the amount of time spent penned. In Schmid's study, the elephants were not continuously maintained in the pens but stayed in them from 0.3 to 8.2 hours per day. In the present study, whenever the elephants were not working, they were penned the rest of each day for the duration of the stay at a penned location. The longer time spent in the pen may have accustomed the elephants to the pen and thus reduced the novelty of the situation. As a result, the elephants in this study may have spent less time in exploratory behaviors than the subjects in the Schmid study.

The elephants in the present study spent almost half the observations (46%) performing stereotypies when chained. Engaging in stereotypies with this frequency greatly reduced their opportunity to perform other behaviors. For instance, the percentage of observations the elephants spent eating, foraging for food, and drinking decreased from 49% when penned to 25% when chained.

The substrate on which elephants are chained is probably not a major determining factor in the occurrence of stereotypies because similar results were observed when elephants were chained on slatted boards [Schmid, 1995], grass or dirt [Friend and Parker, 1999], or macadam [Gruber, 1999]. Rather, it was likely that the chaining contributed to the increase in the display of stereotypies. However, to test this hypothesis, it would be necessary to conduct a study in which the chaining and penning occurred on the same substrate at the same location.

When chained, the elephants are severely restricted in their ability to move, having only enough space for movement of about 1 m forward or backward with little space for sideways movements. This restraint may also inhibit the foraging behavior of the elephants. Elephants in the wild spend 16 to 20 hours per day feeding [Vancuylenberg, 1977; McKnight, 1995; Vinod and Cheeran, 1997]. Although it may not be expected for captive elephants to allocate this amount of time to feeding behaviors, the increase in feeding behaviors, from 25% of observations when chained on macadam to 49% of observations when penned on turf, points to an environmental effect. Food is presented in piles directly in front of the elephants so there is no necessity to forage. With the lack of adequate stimuli to promote species-typical behaviors, the elephants may replace these behaviors with stereotypies.

The expression of stereotypies may enable the chained elephants to cope within their restricted environments, possibly by the release of endogenous opioids [Dantzer, 1991; Mason, 1991]. The decrease in the display of stereotypies, from 46% of observations when chained to 19% when penned, would seem to indicate that the ability to perform more species-typical behaviors may displace the need for the calming effects of performing stereotypies.

The increase in comfort behaviors, from 0.3% of observations when chained to 1.5% when penned, was probably a result of the management system plus the surface on which the elephants were maintained. The most prevalent comfort behavior, spraying, involved tossing dirt, hay, and grass on the head or back. Spraying accounted for 94% of all comfort behaviors when penned and 36% when chained. When penned, however, the elephants had more available material to use for this activity than when they were chained on macadam.

Elephants in the wild rest both standing and lying [Wyatt and Eltringham, 1974] and the present findings found a similar tendency in captive elephants. Type of restraint did not affect the probability of resting activity, but the form of resting varied. The overall probability of lying while resting was greater when penned (34% of observations) than when chained (19%). Individuals varied in the form of resting, which is elaborated on in Gruber [1999], and is consistent with Friend and Parker [1999]. The prevalence to lie more when penned may reflect the difficulties of lying owing to the constraints of chaining. There were times that a few elephants would lie down when chained but were positioned in such a way that adjacent elephants were prevented from lying down. The space available in the pens provided enough room so that all the elephants in a pen could lie down at the same time. The probability of resting (6–7 h/day) was consistent with resting behavior of Asian elephants in one zoo [Tobler, 1992].

The pens in this study were barren, without any form of physical enrichment, such as branches, trees, or bushes. Food was provided in a pile, which was the same manner as when chained, so that the elephants did not need to forage for their food. Although able to socialize with more elephants in the pen than when chained, uninhibited social interactions, as seen in the wild or in larger elephant enclosures, were still not available. Comfort behaviors increased when penned, but some behaviors seen in the wild, such as foot care, could not be performed due to the lack of tools, i.e., branches, in the pens.

Social enrichment affected the expression of stereotypies in pigs [Arellano et al., 1992] and horses [McGreevy et al., 1995] and should be considered as a potential confounding factor in interpreting results from studies of stereotypies in elephants. For example, there was a significant difference in stereotypies between one location where the elephants were penned and the other three penned locations [Gruber, 1999]. One hypothesis would be that this was related to changes in social groupings. For example, an elephant in a pen adjacent to the study subjects was present at three locations but removed at the fourth for health reasons. Such decisions need to be made for husbandry reasons, and these environmental changes are difficult to control in an ongoing study of a working circus. The resulting changes in social groupings should be considered in interpretation of the results of this study and in the design of future research.

Regardless of type of restraint, the occurrence of stereotypies tended to increase between 1500 and 2100 hours. A possible explanation for the increase may involve the fact that the majority of the circus performances occur during this time. Friend [1999] found that stereotypies increased before performance times and suggested that this may indicate an “anticipation” of performances.

The age-related trend identified by Friend and Parker [1999] was even more evident in the present study because of the inclusion of a younger age category (<20 years). When chained, the three oldest elephants displayed the three lowest occur-

rences (14, 15, and 24%) of stereotypies and the three highest occurrences of both ingestion (40, 38, and 33%) and resting (44, 42, and 39%) activities. Conversely, the three youngest elephants displayed the three highest occurrences (83, 86, and 95%) of stereotypies and the three lowest occurrences of both ingestion (3, 8, and 9%) and resting (3, 4, and 7%) activities. The ranges of occurrences for the mid-aged group were 30 to 44% in stereotypies, 23 to 32% in ingestion activities, and 26 to 34% in resting activities. One interpretation would be that the youngest elephants found the restraint of chaining more restrictive than the older elephants.

This study found that stereotypies increased and species-typical behaviors decreased when the elephants were chained as opposed to penned. However, these results may be confounded because of the substrate differences between treatments. Additionally, at one penned location in which social contacts were different, the occurrence of stereotypies increased. As a result, an alternative hypothesis that needs to be tested would be the separate and combined effects of substrate and social groupings on behavior.

CONCLUSIONS

1. The probability of stereotypic behaviors was higher when elephants were leg-chained along a picket line on macadam than when restrained in small groups within electric fences placed on turf.
2. The effect of chained restraint differed among individual elephants, with the youngest elephants more likely to show stereotypic behavior and less likely to show ingestion or resting activities than the older elephants.
3. In contrast to chained restraint on macadam, the social and physical enrichment during penned restraint was associated with more species-typical behaviors.

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REFERENCES

- Adams J, Berg JK. 1980. Behavior of female African elephants (*Loxodonta africana*) in captivity. *Appl Anim Behav Sci* 6:257–76.
- Altmann J. 1974. Observational study of behavior: sampling methods. *Behavior* 49:227–67.
- Arellano PE, Pijoan C, Jacobson LD, Algers B. 1992. Stereotyped behaviour, social interactions and suckling pattern of pigs housed in groups or in single crates. *Appl Anim Behav Sci* 35:157–66.
- Bakeman R, Gottman JM. 1986. Observing interaction: an introduction to sequential analysis. Cambridge: Cambridge University Press. 221 p.
- Brockett RC, Stoinski TS, Black J, Markowitz T, Maple TL. 1999. Nocturnal behavior in a group of unchained female African elephants. *Zoo Biol* 18:101–9.
- Broom DM, Kennedy MJ. 1993. Stereotypies in horses: their relevance to welfare and causation. *Equin Vet Ed* 5:151–4.
- Carlstead K. 1996. Effects of captivity on the behavior of wild mammals. In: Klieman DG, Allen ME, Thompson KV, editors. *Wild mammals in captivity*. Chicago: University of Chicago Press. p 317–33.
- Dantzer R. 1991. Stress, stereotypies and welfare. *Behav Proc* 25:95–102.
- Eltringham SK. 1982. *Elephants*. Dorset, England: Blandford Press. 262 p.
- Fox MW. 1965. Environmental factors influencing

- ing stereotyped and allelomimetic behaviour in animals. *Lab Anim Care* 15:363–70.
- Fox MW. 1968. Abnormal behavior in animals. Philadelphia: W.B. Saunders. 563 p.
- Friend TH. 1999. Behavior of picketed circus elephants. *Appl Anim Behav Sci* 62:73–88.
- Friend TH, Parker ML. 1999. The effect of penning versus picketing on stereotypic behavior of circus elephants. *Appl Anim Behav Sci* 64:213–25.
- Garai ME. 1991. Special relationships between female Asian elephants (*Elephas maximus*) in zoological gardens. *Ethology* 90:187–205.
- Gruber TM. 1999. The effect of penning and chaining on circus elephant behavior. [thesis]. College Station: Texas A&M University.
- Hutt C, Hutt SJ. 1965. The effects of environmental complexity on the stereotyped behaviours of children. *Anim Behav* 13:1–4.
- Martin P, Bateson P. 1993. Measuring behaviour, an introductory guide, 2nd ed. Cambridge: Cambridge University Press. 222 p.
- Mason GJ. 1991. Stereotypies: a critical review. *Anim Behav* 41:1015–37.
- Mason GJ. 1993. Age and context affect the stereotypies of caged mink. *Behavior* 127:191–229.
- McGreevy PD, Cripps PJ, French NP, Green LE, Nicol CJ. 1995. Management factors associated with stereotypic and redirected behaviour in the thoroughbred horse. *Equin Vet J* 27:86–91.
- McKnight BL. 1995. Behavioural ecology of 'hand-reared' African elephants (*Loxodonta africana* (Blumenbach)) in Tsavo East National Park, Kenya. *Afr J Ecol* 33:242–56.
- Moss CJ. 1983. Oestrous behaviour and female choice in the African elephant. *Behavior* 86:167–96.
- SAS/STAT USER'S GUIDE (Version 6). 1996. Cary (NC): SAS Inst. Inc. 1028 p.
- Schmid J. 1995. Keeping circus elephants temporarily in paddocks—the effects on their behaviour. *Anim Welfare* 4:87–101.
- Tobler I. 1992. Behavioral sleep in the Asian elephant in captivity. *Sleep* 15:1–12.
- Vancuylenberg BW. 1977. Feeding behavior of the Asiatic elephant in southeast Sri Lanka in relation to conservation. *Biol Cons* 12:33–54.
- Vinod TR, Cheeran JV. 1997. Activity time budget of Asian elephants (*Elephas maximus L.*) in Idukki Wildlife Sanctuary, Kerala, South India. *Indian Forester* 123:948–51.
- Wiedenmayer C, Tanner R. 1995. Untethered housing of Asian elephants (*Elephas maximus*) at Zurich Zoo. *Int Zoo Yrbk* 4:200–5.
- Wyatt JR, Eltringham SK. 1974. The daily activity of the elephant in Rwenzori National Park, Uganda. *E Afr Wildl J* 12:273–89.