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ARTICLES

The Effects of Visitor Density and Intensity on the Behavior of Two Captive Jaguars (*Panthera onca*)

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Several researchers have reported significant effects of visitor density and intensity on captive animal behavior. This study determined whether this was the case for 2 captive jaguars housed at the Woodland Park Zoo, Seattle, WA. Subjects were monitored for changes in behavior as a function of visitor density and intensity. The jaguars were observed for 8 hr per week for 29 weeks—March 31 until October 11, 1998—for a total of 230 hr. Continuous frequency sampling was used, and visitor density and intensity were recorded every minute. Parametric statistics were used to test for correlations between behavior and density, intensity, or a combination of the two. Both density and intensity were significant for time spent non-visible for both cats, and intensity showed a significant effect on the female's pacing behavior. In addition, the male cat exhibited a trend for increased aggression based on both visitor density and intensity and a trend of intensity affecting his social behavior. In conclusion, both density and intensity had a significant effect on behavior, with intensity showing a larger effect.

The jaguar is the world's third largest cat, yet much about jaguars is unknown. They have not been studied widely either in the wild or in captivity. Both the habitat and population of this species are disappearing at an alarming rate. As this occurs, captive jaguars will become increasingly more important both in learning about this species and in maintaining a viable population; thus, maintaining their health and welfare in captivity is increasingly important.

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Jaguars (*Panthera onca*) are large cats approximately 6 or 7 ft (1.8 m to 2.1 m), long with a weight of up to 112.5 kg (Sleeper, 1995). They have a coloration pattern similar to that of a leopard. They live primarily in the South American rainforest and are a solitary species: The males and females come together only to breed. Their territories range in size from 20 km^2 to 40 km^2, possibly larger (Schaller & Crawshaw, 1980). This species is endangered primarily because of habitat loss. The rainforest that jaguars prefer is being converted for use by human farmers (Sleeper, 1995). Jaguars climb, swim, and walk in their natural environment and need to have the same type of activity in captivity. Being unable to perform the same activities in captivity as they would in their natural habitat can be a cause of stress to nonhuman animals. Although some stress may be needed in a captive environment to induce breeding, too much stress is not healthy for the animals (Carlstead & Shepherdson, 1994) and may bring about stereotypic behavior. Dantzer and Mormede (as cited in Shepherdson, 1989) defined *stereotypic behavior* as a series of regularly repeated movements without an apparent purpose. Shepherdson listed some stereotypic behaviors, such as pacing, bar gnawing, weaving, crib biting, and other normal behaviors that regularly are repeated without an apparent purpose, and stated that these behaviors could be the result of stress from visitors, stress from the enclosure size, the desire to escape an adverse condition in the enclosure, or various other causes. One possibly stressful factor that can have an effect on the behavior of animals on public display is the density (number) and intensity (noise level) of the visitors viewing an exhibit.

Studies correlating human effects to behavior have been conducted—with varying results—on several species. Chamove, Hosey, and Schaetzel (1988) found that visitors increased the activity level of primates, increased the level of aggressive behavior, and decreased nonviolent social behavior. A study of 12 different species of primates found that active audiences influenced the primates to perform significantly more locomotory activity, and to interact more with the audience, than did passive audiences, with larger groups having a greater influence (Hosey & Druck, 1987). A study of wild tigers (Kerley et al., 2002) found that tigers consumed more meat and spent more time at kill sites that were undisturbed by humans. Margulis, Hoyos, and Anderson (2003) studied 6 different species of felids (lion, amur leopard, amur tiger, snow leopard, clouded leopard, and fishing cat) in captive environments and found that the presence of visitors had no effect on any of the species studied; the same results were found for captive cheetahs (O'Donovan, Hindle, McKeown, & O'Donovan, 1993). However, Mallapur and Chellam (2002) found that visitors affected the behavior of captive Indian leopards.

A pilot study performed during the summer of 1997 showed that the jaguars at the Woodland Park Zoo (WPZ) in Seattle, Washington, were reacting to the intensity and density of visitors to the exhibit, with a trend toward increased amounts of pacing and aggression, particularly for the female jaguar. This indicated a need for further study to quantify the effects that visitor density and intensity have on jaguar

behavior. If visitors do have a significant effect on the behavior of jaguars, this effect could affect the jaguars' health, welfare, and breeding success rate in captive environments. Successful breeding in captive environments could determine whether *Panthera onca* will survive as a species. Although these two jaguars were not bred, they did exhibit breeding behaviors, and it was hoped that determining the factors that influence both their behavior and general health would aid in the welfare and breeding of other captive jaguars.

Our general hypothesis was that the amount of pacing and aggressive behavior displayed by the jaguars would increase as the density and intensity of the visitors increased because of an increase in tension in the cats.

METHOD

Subjects

The two jaguars (*Panthera onca*) studied were Jesse, a 10-year-old female, and Gordo, Jesse's 3.5-year-old son. Jesse was born at the Granby Zoo in Montreal, Quebec, Canada, and was acquired by the WPZ on July 5, 1988. Gordo was born to Jesse and her previous companion, Giorgio (WPZ ID No. 870576), at the WPZ. Both subjects were housed in the same exhibit at the WPZ. They both were in the exhibit at the same time and—on a daily basis—were on exhibit for the entire time the zoo was open (D. Wooster, personal communication, March 1998).

Several characteristics differentiated Gordo from Jesse. Gordo was longer and larger and had a heavier build and a broader face than did Jesse. Jesse also had a more acute arch to her back than did Gordo. Prior to this study, Gordo was weighed on February 8, 1996. At that time, he weighed 70 kg; at the time this study was conducted, he was estimated to weigh approximately 90 kg. Jesse was estimated to weigh approximately 70 kg.

The two cats also differed in personality. Jesse had been described as hypersensitive and extremely dangerous, while Gordo had been described as dangerous but mellow. Their keeper, Dana Wooster, attributed Jesse's sensitivity to the fact that she had been hand raised (raised by humans) and had thus learned not to fear humans. Although hand-raised cubs are taught not to use their teeth or claws on humans (Vandermey, Masek, & Losey, 1995), Jesse had twice attacked her keeper (D. Wooster, personal communication, March 1998).

Housing and Maintenance

The two jaguars shared an outdoor enclosure that was approximately 11 m wide, 8 m deep, and 4 m high. The exhibit was enclosed by heavy steel mesh and had a concrete floor and shelves of various heights around the back and left side of

the enclosure. In the back left of the exhibit, there was a concrete shelf that was heated through the fall, winter, and spring. There were two tree structures in the exhibit, one in the left front and one in the right back. There was a small pool filled with water in the back left and three sand pits filled with sand and tree debris in the left and right front and in the left back of the exhibit. In the front right of the enclosure was a hanging platform, henceforth called the *swing*. In the back of the enclosure were two dens that could not be viewed by the public. The jaguars were locked out of the back dens from the time their keeper arrived at the zoo until approximately 1600 hr, when they were fed. The only times that the jaguars were not on display were during severe wind or snowstorms, when they were scheduled to receive vaccinations, or when they were ill.

The jaguars were fed 6 days a week and fasted on the 7th day to provide an approximation of conditions in their natural habitat. Each feeding was 1.13 kg of meat and varied among chicken, mutton, horsemeat, and prepared feline diet. They also received salmon, chicks, trout, and rabbits as treats. To provide enrichment, fennel, mint, nutmeg, and cinnamon, along with various other spices, occasionally were spread throughout their exhibit.

Data Collection Procedure

To ensure sufficient data on seasonal and weather effects, this study was conducted at the WPZ's Zoological Gardens from the spring (March 31, 1998), through the fall (October 11, 1998). Approximately 8 hr a week were spent collecting data, with an average of 2 hr to 4 hr of observation per visit. The study was conducted at different times across all days between the hours of 7:00 a.m. to 8:30 p.m. to control for differing numbers of people throughout the day and differing behaviors exhibited by the jaguars, both before the zoo opened and after it closed for the evening. The exhibit was observed, whether either jaguar was visible or not, for a total of 230 hr.

Continuous focal animal sampling was used to determine the frequency and length of bout of behavior over a 30-min period. The behaviors measured are described in Table 1. All behaviors not otherwise defined were grouped into the category "other." At the end of the study, the behavior noted as "skip pace" also was grouped in the other category because there were insufficient examples of it to perform statistical procedures. The density and intensity of the visitors were recorded at the end of each minute. The intensity levels and density levels are noted in Tables 2 and 3, respectively.

ANALYSIS

At the end of the data collection period, parametric statistics were performed to test for the effect of the predictor variables visitor intensity and visitor density

TABLE 1
Continuous Focal Animal Sampling Used to Determine the Frequency and Length of Bout of Behavior Over a 30-Minute Period

Ethogram Behavior	*Description*
Pacing	Moving around the enclosure with a nonpurposeful walk, defined by a distinct repetitive pattern
Skip pace	Animal starts pace cycle by hoping into the air from standing position, then walks very quickly in pattern
Aggression	Threatening interaction between jaguars; can be snarls, growls, snaps, bites
Social	Nonthreatening interaction between jaguars; can be play, grooming, nuzzling
Nonvisible	Not in observer's field of vision
Other	Any behavior not defined above

Note. Skip pace was grouped into the other category during analysis.

TABLE 2
Intensity Levels and Codes

Level	*Rating*	*Definition*
Quiet	1	Quiet whispers, no loud talking
Low	2	Quiet talking, two or fewer bouts normal talking
Moderate	3	Normal talking, no shouting
High	4	Normal talking, two or fewer bouts shouting
Extreme	5	Loud talking and/or more than two bouts shouting

Note. A *bout* of noise level is defined as lasting up to 5 sec in duration.

TABLE 3
Density Levels and Codes

Level	*Rating*	*Definition*
Quiet	1	1 to 10 people
Low	2	11 to 20 people
Moderate	3	21 to 30 people
High	4	31 to 40 people
Extreme	5	41 or more people

on behavior. In addition to density and intensity, additional predictor variables recorded and analyzed were cat ID, day of the week, time of day, weather, and (for Jesse) estrus cycle status.

As each observation was not necessarily an independent event, the degrees of freedom required adjustment. This was done by using two methods. First, the day number was included with the analysis: It was used to partition more appropriately the degrees of freedom and to deal partially with the independence issue. Second, to address further the independence issue, interpretation of significance was restricted to probabilities ≤ .01, rather than the more conventional alpha level of .05.

The results were analyzed by using a multiple general linear model, combining both categorical (analysis of variance) and continuous (regression) predictors into a single analysis. The dependent variables were the duration (minutes) of a given behavior in a 30-min observation period. Social independence of data points between the two animals was confirmed: Behavior of the two animals was independent of each other. Data met the normality and homoscedasticity assumptions of parametric statistical analysis: Tests of skewness, kurtosis, and heteroscedasticity were nonsignificant at the $p = .05$ level. Interaction terms in the general linear model allowed for the accommodation of potential interactions between predictor variables.

RESULTS

Density

For both cats, visitor density was shown to have a significant effect on time spent nonvisible: female, $F(2, 306) = 6.17$, $p = .0023$; male, $F(2, 317) = 5.91$, $p = .0030$, with both cats spending the most time nonvisible at the lowest density level but not on any other behavior measured (see Figure 1). Pacing: female $F(2, 1544) = 0.023$, $p = .980$; male NA; social: female $F(2, 98) = 0.92$, $p = .40$; male $F(2, 55) = 1.16$, $p = .32$; and aggression: female $F(2, 25) = 0.38$, $p = .69$; male $F(1, 5) = 8.23$, $p = .035$, showed no significance, although the male did exhibit a trend for increased aggression at higher densities of visitors.

Intensity

The results from the analysis for the effects of increasing visitor intensity across behavior vary slightly by cat. The pacing behavior of the female was shown to be affected significantly by intensity, $F(4, 1544) = 11.70$, $p < .0001$, with her longest bouts of pacing at Intensity Level 2 (see Figure 2), but the male exhibited no pacing at any time. The social behavior of the male showed a trend toward significance, $F(4, 55) = 2.72$, $p = .039$, but the female showed no such

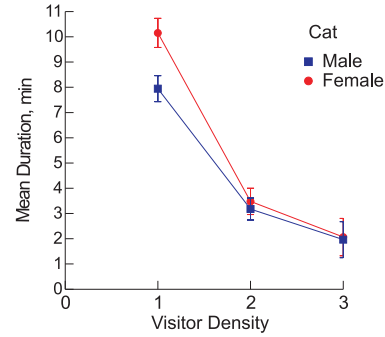

FIGURE 1 Effects of visitor density on the mean length of nonvisible bouts for both cats. Error bars represent 1 standard error.

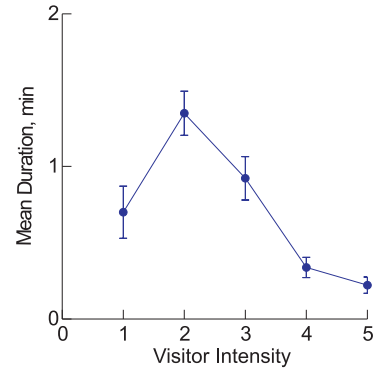

FIGURE 2 Effects of visitor intensity on the mean length of pacing bouts for the female cat. Error bars represent 1 standard error.

trend, $F(4, 98) = 1.71$, $p = .15$. Both cats showed significance for intensity effects in nonvisible behavior: female, $F(4, 306) = 15.015$, $p < .0001$; male, $F(4, 317) = 10.61$, $p < .0001$, with both cats spending the most time nonvisible at the lowest intensity level (see Figure 3). Intensity was not shown to have an effect for either cat in regard to aggression: female $F(3, 25) = 0.055$, $p = .98$; male $F(2, 5) = 5.48$, $p = .055$, although the male exhibited a trend for it.

Time of Day

The results show that time of day (TOD) had a significant influence on the female's pacing behavior, $F(1, 1{,}544) = 54.339$, $p < .0001$, with more pacing occurring as it neared 1500 hr, with a sharp drop after 1600 hr (see Figure 4). Time of day had no effect on male pacing behavior, as he evidenced no pacing, but it did have an effect on the nonvisible behavior of the male, $F(1, 317) = 20.62$, $p < .0001$, with the time the male spent nonvisible decreasing as TOD increased until 1600 hr, at which point his nonvisible time started increasing again (see Figure 5). However, TOD showed no significance for the female, $F(1, 306) = 1.30$,

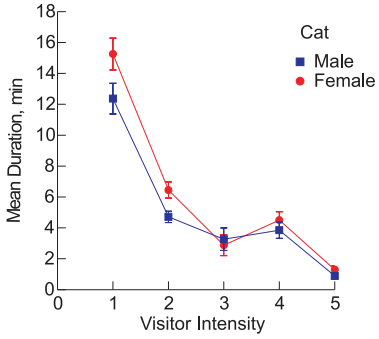

FIGURE 3 Effects of visitor intensity on the mean length of nonvisible bouts for both cats. Error bars represent 1 standard error.

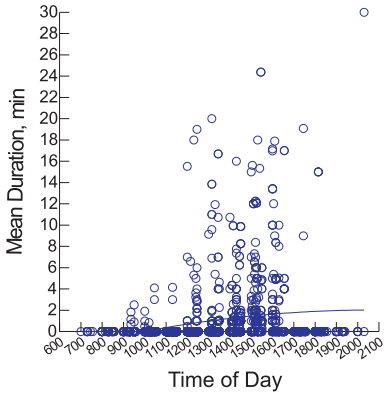

FIGURE 4 Effects of time of day on pacing by the female jaguar.

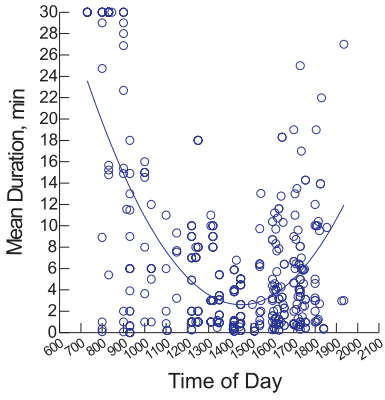

FIGURE 5 Effects of time of day on the length of bouts of nonvisible behavior by the male jaguar.

$p = .25$. Social behavior: female $F(2, 98) = 0.92$, $p = .79$; male $F(1, 55) = 3.38$, $p = .07$, and aggression: female $F(1, 25) = 0.12$, $p = .73$; male $F(1, 5) = 3.29$, $p = .13$, showed no significance for TOD.

Weather

Weather was not shown to have any significant effect on any behavior. Pacing: female $F(5, 1{,}544) = 0.73$, $p = .60$; male NA, social behavior: female $F(5, 98) = 1.31$, $p = .27$; male $F(4, 55) = 0.29$, $p = .88$; aggression: female $F(4, 25) = 2.16$, $p = .10$; male $F(2, 5) = 6.20$, $p = 0.04$, and nonvisible behavior: female $F(5, 306) = 0.56$, $p = .73$; male $F(5, 317) = 0.78$, $p = .57$, all showed no significance; however, the male did exhibit a trend for aggression.

Estrus

Estrus was not shown to have any significant effect on any behavior. Pacing: female $F(2, 1{,}544) = 0.14$, $p = .87$; male NA, social behavior: female $F(3, 98) = 0.19$, $p = .90$; male $F(1, 55) = 0.0054$, $p = .94$; aggression: female $F(1, 25) = 0.037$, $p = .85$; male NA; and nonvisible behavior: female $F(2, 306) = .066$, $p = .94$; male $F(3, 317) = 0.56$, $p = .64$; all showed no significance.

DISCUSSION

As shown here, three of the predictor factors had a significant effect on the behavior of the two cats. Visitor intensity has been shown to have a larger effect on behavior as it significantly affected two behaviors in the female (pacing, non-visible behavior) and one in the male (nonvisible behavior), with trends for two others (aggression, social). In contrast, density significantly affected only one behavior in the female and male (nonvisible behavior for both) and showed a trend toward affecting a second behavior in the male (aggression). This is contrary to the effect found by Chamove et al. (1988) and Hosey and Druck (1987). When they studied primate behavior in a zoo setting; they had found that both density and intensity strongly influenced behavior. The results also challenge the results from Margulis et al. (2003) and O'Donovan et al. (1993), both of whom found no effect of visitor presence on six species of felids: lion; amur leopard; amur tiger; snow leopard; clouded leopard; fishing cat; and also captive cheetahs. The differences between these findings may be due to the techniques used to measure density and intensity and the methods used to analyze visitor effects. It also might be due to the different social behaviors exhibited by the species studied. Because the primates studied usually live in groups, they might not experience the same stress by being on exhibit that a primarily solitary animal

might when forced to deal regularly with potential competitors for food and resources (Sunquist & Sunquist, 2002).

That the female paced more during times of a relatively low intensity level may be due to several factors. Because it was not possible to isolate intensity levels from each other, the female still could have been reacting to a prior level of intensity. In addition, the visitors to the exhibit could have been reacting to the female's pacing behavior by moderating their tone of voice. Third, the female could have felt the most stress during those times that the visitors were speaking in lower voices. There also could have been another factor that affected the female during Level 2 intensities: a hormone released from the visitors that the observer was not able to perceive. Moreover, a combination of factors might have produced this effect.

Another factor to consider within this study is the relationship between the lowest density and intensity levels and the time both cats spent in nonvisible behavior. When both cats were nonvisible, visitors to the exhibit frequently and quietly walked past without pausing. As the time that the cats were locked outside varied from day to day without prior notice, it was not possible to determine whether the cats were engaging in nonvisible behavior because of the low crowd density or intensity or if the crowds were reacting to the nonvisible behavior in which the cats were engaged.

Lack of control over the environment might be another factor for the stress exhibited by the cats. Because animals living in their natural habitat can regulate behavior in response to the stimuli present, they have a greater degree of control over that stimuli and the effect that stimuli have on their behavior than do animals faced with similar stimuli in a captive environment. Deer mice allowed to control the lighting in their environment by the use of a lever will turn the light off each time it automatically comes back on, which illustrates their natural aversion to bright lighting (Joff, Rawson, & Mulick, 1973). However, if the light is turned off automatically, the mice will push the lever to turn the light back on, seemingly to experience the reward of controlling the light level in their environment. The stress caused to an animal by its lack of control over the environment can have potentially devastating effects. This stress may be redirected to inappropriate behaviors, such as copulating with inappropriate partners or unexpected aggression toward other animals who have shared the exhibit for a long period with no prior issues (Meyer-Holzapfel, 1968). As individual animals exhibit individual responses, an animal who exhibits a conservation–withdrawal response, such as hiding in a corner, might be experiencing as much, or more, stress than an animal who exhibits a fight-or-flight response such as pacing (Carlstead, 1996).

Because the jaguars in this study had little control over their environment and the visitors outside their exhibit, the stress that they experienced resulted in significant changes in undesirable behaviors, including pacing and the time they spent hiding in areas considerably smaller than the exhibit. Both the male and female were affected by their inability to leave the viewing area of their exhibit before

1600 hr. The female showed an increase in the time spent pacing as the time approached (1600 hr) when the doors to their back rooms were opened; the male showed an increase in time nonvisible once the doors to the back were open and he could choose where to spend his time.

It is important to keep in mind the effect that prolonged stress may have on the health and welfare of an animal in addition to the effect on the animal's behavior. In humans, prolonged exposure to stress has been linked to many different physical problems: stomach ailments, headaches, and increased blood pressure.

Humans primarily are social creatures, accustomed to living and working together. For a primarily solitary animal such as a jaguar, constant exposure to high levels of zoo visitors, with the associated increased level of noise, can produce a level of stress with which their physical bodies may not be equipped to deal and may precipitate a variety of physical ailments. Furthermore, prolonged stress in humans also can affect emotional state, causing a psychological disorder. In the case of the jaguars we studied, the stress may have had the effect of causing unexpected aggression between the two cats after this study was concluded. During the construction of a new exhibit for the jaguars, located relatively close to the old exhibit and increased the noise level at their exhibit, the male exhibited greatly increased aggression levels (D. Wooster, personal communication, May 2003). Thus, reducing the density and intensity of visitors may reduce the amount of stress experienced by solitary animals on exhibit in the same enclosure and may be paramount to maintaining their health and increasing their general well being.

In addition to the effect that this stress might have on the animals' overall health and welfare, prolonged stress can significantly affect breeding of captive animals (Carlstead & Shepherdson, 1994). If an animal is not able to cope with the stress of a captive exhibit, then breeding that animal may become extremely difficult. When the species in question are endangered, this effect of stress might reduce the overall ability of humans to maintain a breeding population.

CONCLUSIONS

The intensity and density of the visitors to the WPZ had a significant effect on the behavior of the jaguars we studied, and visitor intensity had much more of an effect. Time of day also had a significant effect on behavior; however, weather and feeding were not significant in influencing behavior of the two jaguars. Because this study indicates that the effects of intensity and density on the behavior of the two cats causes prolonged stress, further research is needed to determine whether similar effects occur in other captive situations for jaguars and other large cats. If similar effects do occur, it is recommended that a method be found to reduce the amount of prolonged stress the animals experience and thus increase overall health and the animals' welfare. This information could be vital in maintaining a healthy breeding population.

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