JOURNAL OF APPLIED ANIMAL WELFARE SCIENCE, *9*(4), 269–276

The Effect of the Captive Environment on Activity of Captive Cotton-Top Tamarins (*Saguinus oedipus*)

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This study examined captive cotton-top tamarin (*Saguinus oedipus*) behavior across 3 different exhibits: (a) a rainforest (30.5 m in diameter), where tamarins free-ranged with other species; (b) a caged outdoor exhibit (5 m in diameter); and (c) a caged enclosure, with access indoors (6 × 9 m) and outdoors (2.5 × 2.5 m). The study observed tamarins using focal animal scan sampling in 10 min blocks. Scoring was on the percentage of intervals in which they engaged in 12 behaviors. The findings show significant differences in activity, inactivity, and visibility across exhibits and have important implications for reintroduction efforts.

Research involving endangered primate species has often focused on conservation efforts that will increase survival and reproduction in the wild. One effort for producing long-term survival of species is *reintroduction attempts*, returning captive, nonhuman animals back to native environments. Unfortunately, reintroduction still faces some challenges. Beck, Rapaport, Price, and Wilson (1994) investigated 145 separate reintroduction projects and found that only 11% were successful at reaching self-sustaining populations. This suggests that many animals may not learn survival skills living in captive settings; the captive environment may not offer challenges similar to the wild environment. Some problems arboreal primates face living in captivity include not developing proper use of substrates, foraging skills, and locomotor skills (Novak, O'Neill, Beckley, & Suomi, 1994).

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The golden lion tamarin (*Leontopithecus rosalia)* is one species that has been a subject of reintroduction attempts (Beck & Castro, 1994; Beck, Castro, Stoinski, & Ballou, 2002; Stafford, Rosenberger, & Beck, 1994; Stoinski, Beck, Bloomsmith, & Maple, 2003). Beck et al. found that repatriated captive-born golden lion tamarins are less likely to survive than their wild-born offspring. This is important because it demonstrates that the captive animals who did survive and reproduce in the wild were still less successful at adapting to the environment than the offspring they produced.

Similarly, Stoinski et al. (2003) compared reintroduced tamarins to their wild-born offspring and found that the captive environment may inhibit the development of certain skills. Captive-born golden lion tamarins were deficient in locomotor and foraging skills compared with their wild offspring. Thus, scientists should dedicate more effort to facilitating learning of the skills necessary to survive in a species' native habitat. In addition, Beck et al. (2002) showed that captive, reintroduced tamarins had to adapt to the changes in a wild environment and noted that perhaps captive tamarins are not challenged enough in the captive setting to be able to adapt to dynamic situations when placed back in their native environment.

Captivity has, however, been largely understudied regarding its effect on behavior. Novak et al. (1994) performed one study that investigated captivity and discovered that one element, cage size, plays an important role in primates' development of natural skills. Novak et al. found that limited cage sizes produced abnormal locomotor patterns in spider monkeys.

Another study, conducted by Glatston, Geilvoet-Soeteman, Hora-Pecek, and van Hooff (1984), examined the on-display aspect of captive environments. For animals housed in enclosures available to the public, such as zoos, there is the added stress of constant vigilance of observers, which may also influence behavior patterns. Glatston et al. compared cotton-top tamarin social interactions on display and off display and found that there was less social behavior demonstrated when on display.

These limited studies on the effects of captive environments demonstrate a need to further understand the effects of habitat on the behavior of captive, endangered species if conservation efforts continue to focus on reintroduction. It is important to determine whether different types of captive habitats differentially affect the development of skills appropriate to living in the wild and if the habitat is dynamic enough to encourage flexibility of behavior.

Thus, the purpose of this study was to compare the behavior of cotton-top tamarins across three exhibit types at a zoo. These tamarins were chosen for this investigation because, for management purposes, they were moved across exhibit types that differed in size, access to the outdoors, and availability to the public. We hypothesized that the captive environment would differentially affect activity levels of the cotton-top tamarins. More specifically, we predicted that the most com-

plex and dynamic exhibit (the rainforest) would elicit greater activity and a greater range of behaviors in which the animals engaged.

METHOD

Subjects

Description of subjects. The subjects were 4 cotton-top tamarins (*Saguinus oedipus*) at the Topeka Zoo (Topeka, Kansas). All 4 were siblings from the same mated pair. Sage was the only female and the smallest of the four tamarins. She was a twin of Gemini; they were 2 years old at the beginning of the study. Chan and Tad were older twinned siblings and were 3 years old at the start of observations. The 4 animals were visibly distinguishable. They were all born at the Topeka Zoo.

Housing and care. The tamarins were all housed at the Topeka Zoo in three different exhibits. The cotton-top tamarin enclosure at the beginning of observations was a rainforest, a large, domed building with windows. The rainforest is 30.5 m in diameter, a building filled with many plants that are tropical and common to rainforests. The trees are most dense at the center of the building and around the interior wall. There is a circular path in the rainforest, on which visitors can walk and view the animals. Except for a few caged exhibits, most of the animals range freely. Thus, the rainforest environment is a dynamic interplay of growing vegetation, a multiplicity of free-ranging species, and transient visitors. The tamarins were supplied with one nest box in a back area of the rainforest that was not available to visitors. The humidity varied often throughout the day, as misters were used to simulate rain. Keepers would supply food and water for the tamarins in the morning and afternoon (approximately 10:00 a.m. and 3:00 p.m.).

In May, after approximately 2 months of observations, the tamarins were moved to an outdoor enclosure (5 m in diameter) where they could be viewed from all sides. The summer outdoor enclosure had no live plants on which they could feed. The new enclosure had severed tree limbs secured vertically and horizontally, which allowed for locomotion. They also had a nest box and several large, hollowed-out logs; this enclosure had little variation in it from day to day except for weather and small animals and insects that travel through or near the exhibit. A keeper fed the tamarins at approximately 10:30 a.m. and again in the afternoon at approximately 2:30 p.m. In this new exhibit, the keeper was in the environment after the morning feeding for 1 to 1.5 hr cleaning the enclosure.

In October, the tamarins were again moved to an indoor–outdoor exhibit (6 × 9 m indoors and 2.5 × 2.5 m outdoors) that allowed for shelter from the colder weather. On the interior, the exhibit had several potted plants, a man-made water-

fall and cement "tree," a nest box, severed tree limbs secured horizontally, and artificial lighting. The exterior portion of the exhibit had live trees, a nest box, a small tire swing, and more tree limbs secured for locomotion. This exhibit also had little daily variation, except in offering the tamarins the choice of being outdoors or remaining in the interior portion. The outdoor portion offered variability in weather and possible access to insects. The interior was viewed from one side, and the exterior could be viewed along three sides. Keepers fed the tamarins at approximately 10:00 a.m. and 2:30 p.m.

Apparatus

A Sony tape player signaled 1-min time intervals for 10-min periods. At the sound of a tone, the observer was cued to scan and record behaviors. Time, date, weather, and notes were recorded on data sheets. Individual behaviors were recorded on the data sheets at the timed intervals for each monkey.

Procedure

The cotton-top tamarins were observed using focal animal scan sampling (Altmann, 1974) to record each individual's behaviors. The scans were completed in 10-min periods at 1-min intervals. The cotton-top tamarins were scored on 12 different behavior and behavior-related characteristics: (a) eating, (b) hunting, (c) self-grooming, (d) social grooming, (e) sitting, (f) moving, (g) social play, (h) aggression, (i) calling, (j) investigating, (k) behaviors they were engaged in other than the behaviors listed, and (l) whether they were out of sight of the observer. Definitions of these behaviors are presented in Table 1. The observations were balanced across time of day and day of the week. There were 67 total observations for each animal from May to December 2003. There were 17 observations completed in the rainforest, 29 observations in the outdoor exhibit, and 21 observations in the indoor–outdoor exhibit.

RESULTS

The tamarins were scored on the mean percentage of the intervals, per observation, they engaged in each of the 12 behaviors. The behaviors were subsequently grouped into three categories (active, inactive, and not visible) for data analysis (see Table 1). The mean percentage of intervals tamarins engaged in each category of behaviors as a function of exhibit type is depicted in Figure 1.

TABLE 1
Ethogram of Tamarin Behaviors

Behaviors	*Definitions*
Active	
Moving	Climbing, running, or jumping along trees or walls of enclosure
Eating	Pulling bark and fruit from trees or food pans
Grooming	In a group of two or more, picking through hair and cleaning each other
Self-grooming	Picking through hair, cleaning, or scratching at self
Hunting	Watching for small vertebrates, capturing vertebrates
Investigating	Looking at people or animals in area (other than tamarins), coming close to them, sniffing, or peering into windows of enclosure
Social play	Nonaggressive interaction with other tamarins, pushing or rolling over each other, lying calmly on one another, not grooming
Aggression	Scratching at another tamarins face, pushing or picking at another tamarin, making threatening or warning motions, and short call vocalizations
Calling	Long vocalizations that are directed towards other tamarins, or other animals
Other	Any behavior not included in ethogram
Inactive	
Sitting	Stationary position, usually on tree branches or other surfaces, possibly moving head about
Not visible	Animal is out of observers' sight, in separate part of exhibit or in nest box, obscured by foliage

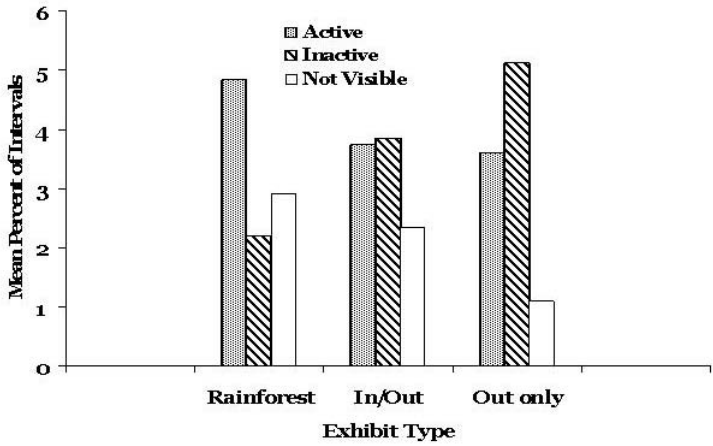

FIGURE 1 Mean percentage of intervals tamarins were active, inactive, and not visible across three exhibit types.

A one-factor repeated measure analysis of variance was performed on each of the behavioral categories (active, inactive, and not visible). The data indicate there were significant differences in activity across the three exhibits, $F(2, 6) = 11.45$, $p = .01$. Post hoc paired t tests ($p < .05$) show that tamarin activity was greater in the rainforest ($M = 4.84$, $SD = 2.79$) compared with the outdoor exhibit ($M = 3.60$, $SD = 2.30$), and the indoor–outdoor exhibit ($M = 3.74$, $SD = 2.13$). Activity in the outdoor exhibit did not differ significantly from that in the indoor–outdoor exhibit.

There was also a significant difference exhibited in the amount of time spent inactive, $F(2, 6) = 28.62$, $p = .01$. Post hoc paired t tests ($p < .05$) showed that the tamarins were most inactive in the outdoor exhibit ($M = 5.12$, $SD = 2.65$), less inactive in the indoor–outdoor exhibit ($M = 3.86$, $SD = 2.19$), and least inactive in the rainforest ($M = 2.21$, $SD = 1.75$). Thus, all three exhibits were found to differ significantly in how inactive the tamarins were.

The last analysis of variance shows that the monkeys were not equally easy to locate in the different exhibits, $F(2, 6) = 7.41$, $p = .05$. Post hoc paired t tests ($p < .05$) show that the tamarins were most difficult to locate in the rainforest ($M = 2.91$, $SD = 3.46$), and in the indoor–outdoor exhibit ($M = 2.33$, $SD = 3.08$), compared with the outdoor exhibit ($M = 1.10$, $SD = 1.94$). Visibility of the monkeys was not significantly different between the rainforest and the indoor–outdoor exhibit.

DISCUSSION

The results support the original hypothesis that the most complex and dynamic exhibit (the rainforest) would elicit the greatest amount of activity. The tamarins were found to be more active in the rainforest compared with both of the other exhibits, even when they were also less visible in the rainforest. They were also found to be most inactive in the outdoor exhibit, the smallest exhibit, which perhaps allowed less area for locomotion. The outdoor exhibit also had fewer surfaces, less substrate, and no other nonhuman species with which to interact. In addition, although it had a nesting box where the tamarins could hide from viewers, the outdoor exhibit was open to full view by visitors on all four sides. The reduced activity of the tamarins in the outdoor exhibit may be due to being constantly on display because animals on display are less active than animals off display (Glatston et al., 1984). However, the greater inactivity may also be due to the greater visibility. It is possible that the tamarins in the other two exhibits were inactive when they were not visible.

The results of this experiment indicate the importance of the habitat in which tamarins are housed in captivity. The environment may play an important role in what skills these New World monkeys develop. This has great implications for conservation efforts that involve reintroducing animals back into natural habitats; important skills, such as foraging, have been shown to influence tamarin

survival rates after reintroduction attempts (Beck et al., 2002). Thus, when researchers address reintroduction, the captive environment in which the animal resides before reintroduction attempts should be carefully designed to be complex and dynamic, characteristics that encourage the development of locomotor and foraging skills.

However, poor locomotor and foraging skills are not the only problems reintroduced monkeys face. Too often, captive monkeys have little fear of their environment, including the large animals (human visitors to the zoo) who pass through it. This is evidenced by the problem of habituation to visitors, which is what prompted the tamarins involved in this experiment to be moved to the enclosed cages. If reintroduced monkeys lose even some fear of their environment, they may easily fall prey to predators. Behavioral training may be the answer to habituation; tamarins could be subjected to learning techniques that increase cautious behavior patterns.

Further research should focus on ideal training techniques to allow tamarins to develop and hone skills necessary to survive in the wild. Enrichment activities could also be examined to allow for the production of the most adaptive behaviors. Researchers should examine ideal structures and determine what captive environments afford monkeys in promoting the development of species-typical behaviors. These changes to how animals are housed before reintroduction attempts may significantly affect survival and the ability of the animals to adapt to their native habitats. However, it is important that these habitat adjustments be empirically assessed.

The long-term survival of tamarin species depends on their ability to adapt and reproduce within their wild environment. Reintroduction of captive individuals may be the best means of restoring wild populations and warding off extinction. Successful reintroduction requires a greater repertoire of natural behaviors. This study is important in that it offers empirical evidence that captive settings do significantly affect behavior. More attention should be paid to the captive environment to encourage naturalistic behavior in captive animals, which is also tied to psychological well-being (Novak et al., 1994).

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