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Effects of environmental enrichment on behavioral expression of pumas (*Puma concolor*) under human care

*Efeitos do enriquecimento ambiental na expressão comportamental de onças-pardas (*Puma concolor*) mantidas sob cuidados humanos*

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ABSTRACT: The maintenance of pumas under human care imposes different conditions from those found in the natural environment, which may result in stress and impaired welfare. The objective was to evaluate the effects of environmental enrichment on the welfare of four jaguar specimens (*Puma concolor*), kept under human care. The enrichment techniques addressed were food, sensory, and mixed (physical-cognitive) enrichment. The research was divided into three phases: Phase 1, pre-enrichment; Phase 2, application of enrichment; and Phase 3, post-enrichment. The observation of the activities was performed using the focal animal method, and the behaviors were recorded to compose an ethogram. The sampling effort totaled 96 hours, with a 24-hour observation time for each specimen. During phases 2 and 3, the animals showed increased expression of natural behaviors, increased exploration and interaction with the enclosure, as well as, with other individuals. In addition, the applied activities provided cognitive challenges and reduced the animals' idle time. Although puma 4 showed stereotyped behavior, during the three phases of this study, this individual was healthy and active. Thus, the results demonstrate the beneficial effects of environmental enrichment on the well-being of pumas held in captivity.

KEYWORDS: ethogram; ethology; stress, felids.

RESUMO: A manutenção de onças-pardas mantidas sob cuidados humanos impõe condições diferentes daquelas encontradas no ambiente natural, o que pode resultar em estresse e prejuízo ao bem-estar. Objetivou-se avaliar os efeitos do enriquecimento ambiental no bem-estar de quatro espécimes de Onça-parda (*Puma concolor*), mantidos sob cuidados humanos. As técnicas de enriquecimento abordadas foram o enriquecimento alimentar, sensorial e misto (físico-cognitivo). A pesquisa foi dividida em três fases: Fase 1; Pré-enriquecimento, Fase 2; Aplicação dos enriquecimentos e Fase 3; Pós-enriquecimento. A observação das atividades foi realizada através do método animal focal, sendo registrados os comportamentos para composição de um etograma. O esforço amostral totalizou 96 horas, com o tempo de observação de 24 horas para cada espécime. Durante as fases 2 e 3, os animais apresentaram aumento da expressão de comportamentos naturais, aumento da exploração e interação com o recinto, assim como, com os outros indivíduos. Além disso, as atividades aplicadas proporcionaram desafios cognitivos e reduziram o tempo ocioso dos animais. Embora a Onça-parda 4 tenha apresentado comportamento estereotipado, durante as três fases deste estudo, este indivíduo mostrou-se saudável e ativo. Dessa forma, os resultados demonstram os efeitos benéficos do enriquecimento ambiental no bem-estar de onças-pardas mantidas em cativeiro.

PALAVRAS-CHAVE: etograma; etologia; estresse; felídeos.

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INTRODUCTION

Puma (*Puma concolor*) is the second largest felid in Brazil. The species is found in a variety of environments, from forests to savanna formations (ICMBio, 2017). The loss of the natural environment and illegal hunting are the main causes for the decline in the population of these individuals (ICMBio, 2017). Thus, wildlife keepers, conservationist breeders, and zoos are important organizations for the *ex-situ* conservation of this species (Adania *et al*, 2014).

Although keeping pumas under human care is common, this practice imposes very different conditions from those found in their natural habitat, which can result in stress and harm to their welfare (Campos *et al*. 2005; Adania *et al*, 2014; Beresca, 2014). Thus, employing strategies that can promote greater comfort for these animals is essential.

Environmental enrichment inserts stimuli into the environment, which minimizes the effects of the "occupational void" felt by the animals, besides contributing to the maintenance of physical and mental health and offering comfort. The types of environmental enrichment can be divided into physical, sensory, cognitive, social, mixed, and food, with activities that consider the anatomical, physiological, and behavioral peculiarities of each individual (Orsini; Boldan, 2006; Beresca, 2014).

The data obtained from observations can be used to measure the effectiveness of environmental enrichment. To this end, the construction of ethograms, which are tabular representations of the qualification and quantification of behaviors exhibited by an animal species, are crucial, as they allow, among other things, measuring the effectiveness of the enrichment applied (Del-claro, 2004).

We believe that the use of environmental enrichment will result in behavioral expressions different from those observed prior to its application, and may offer the animals greater comfort, as well as behavioral changes. Therefore, the present study aimed to describe the behavioral alterations associated with the use of environmental enrichment on the welfare of puma (*Puma concolor*) specimens kept under human care.

MATERIAL AND METHODS

The work was approved by the Ethics Committee on Animal Use of the Palotina Sector of UFPR (CEUA/Palotina), under Protocol No. 37/2019.

The study was carried out at Daniel Galafassi Municipal Zoo (24°56'57'.1"S and 53°25'57'.9"W), in the municipality of Cascavel/PR. All *Puma concolor* specimens, two males (Pumas 1 and 2) and two females (Pumas 3 and 4), kept by the zoo, were evaluated. The specimens lived in a single enclosure with a total area of 147.68 m², of which 22.86 m² were for the management area. The enclosure was composed of a concrete substrate covered by soil, sand, and vegetation; the walls were made of concrete, except for the ceiling and the part visible to the public, which had iron railings. The environment had tree trunks, a wooden platform and a rest area away from the public, as well as a water tank that served as a drinking and bathing place.

The animals were identified based on their external characteristics, such as sex, coloration, size, and marks/scars (Fig. 1). The age range of the specimens was estimated between 3 and 4 years (pumas 1 and 4); 7 years (puma 2) and 9 years (puma 3).

To verify the effect of environmental enrichment, the study was divided into three phases. In Phase 1 (F1), pre-enrichment, the behavioral categories of each individual were obtained and described. In Phase 2 (P2), application of the enrichments, the individuals were contained in the changing area for the arrangement of enrichments in the enclosure, and then they were released one by one for better behavioral observation. In Phase 3 (P3), post-enrichment, the individuals were evaluated for their behaviors after the application of environmental enrichments.

Assessments were conducted during three weeks in the spring, each corresponding to a distinct study phase, totaling 96 hours of sampling effort. Each animal was observed for two hours daily, totaling eight hours of daily observation on four consecutive days.

In F1 and F3, the individuals were observed individually for two hours, two individuals in the morning and two in the afternoon. To avoid distortions, the organization of the observation times for each specimen was done in a rotating format.

In F2, individuals were observed separately for one hour in the morning and in the afternoon, totaling two hours per day per individual. Two different environmental enrichment types were applied each day, one in the morning and one in the afternoon.

On the first F2 day, sensory enrichment was used, with lemon juice in the morning and cumin in the afternoon, both placed in areas where the animals frequently walked, and the

Figure 1. Puma (*Puma concolor*) specimens resident at Danilo Galafassi Municipal Zoo. (1) Puma 1, male. (2) Puma 2, male. (3) Puma 3, female. (4) Puma 4, female.

points of the afternoon enrichment were different from the morning enrichment. In total there were five spots for lemon juice and five spots for cumin in the enclosure.

On the second F2 day, physical enrichment was provided (Fig. 2). In the morning, three dried coconuts were arranged to simulate a ball at points visible to the specimens. The fruits were properly cleaned and without the water without juice. In the afternoon, the coconuts were collected, and three massaging brushes were attached with sisal rope to the enclosure railing.

Figure 2. Physical enrichment application in the enclosure of pumas (*P. concolor*). (1) Dried coconut placed on a wooden trunk. (2) Massager attached to the enclosure grid with sisal rope.

On the third F2 day, physical enrichment was used. In the morning, four scratchers made of sisal rope were fixed on trunks in the enclosure, at spots that the individuals already used to sharpen their claws. In the afternoon, four bales of hay were placed in the enclosure, and after being used as enrichment, the material was incorporated into the vegetation cover of the enclosure.

Dietary enrichment was applied on the fourth day of F4, with the provision of additional animal protein to the standard diet. In the morning, 16 halved dried coconuts containing hay and 225g of beef were provided at hidden points in the enclosure. In the afternoon, pieces of meat (225g) were attached to sisal ropes at points visible to the individuals.

The behaviors were recorded by focal animal technique, as described by Del-Claro (2004), at a distance of approximately five meters and using a stopwatch to measure behavior duration. The data obtained were recorded in a spreadsheet for later ethogram preparation, based on the studies by Prazeres *et al.* (2010) and Buhr (2018).

Behaviors were divided into two categories: active and inactive (Table 1). The frequency of the behaviors and their execution time were verified, comparing them in the three observation phases.

Table 1. Categories and behaviors recorded during the ethogram with puma (*P. concolor*) at Danilo Galafassi Municipal Zoo.

Category	Behaviors	Behavior Description
Active	Stereotyped Behavior (SB)	Animal walking from side to side repeatedly;
	Locomotion (L)	Walking, running, and jumping around the enclosure;
	Observation (O)	Animal with eyes fixed on the off-show room/area, visitors, and other animals;
	Maintenance (M)	Self-cleaning, drinking water, urinating, defecating, scratching neck, stretching, and sharpening claws;
	Exploration (E)	Animal sniffing the ground, trunk, and plants; digging; animal in station performing "back and forth" movements with the thoracic limbs on the ground;
	Alimentation (A)	Animal sniffing, chewing, and/or ingesting the food; animal with the food in its mouth and walking around the enclosure;
	Vocalization (V)	Animal emitting meows, hisses, and growls;
	Interactions (I)	Animal at station, sitting or lying down, attentive to noises outside the enclosure; animal at station or walking inside the water tank; animal approaches attendant through the off-show grid, growling or purring; animal approaches, rubs or fights with other individuals; animal rubs, rolls, or plays with the vegetation in the enclosure;
	Copulation (C)	The female crouches in prone position, close to the ground, in a receptive sexual posture;
	Interaction with Enrichment (IE)	Animal sniffs, plays, licks, rubs, sharpens claws, rolls, bites, grabs, and/or eats the enrichments;
Inactive	Resting (R)	Animal lying with body extended and with or without eyes closed; animal standing in sphinx position;
	Hiding (H)	Animal remains in the off-show area/ refuge area.

RESULTS

During F1, the behaviors frequently performed by the individuals were R and L, with greater expression by males in relation to females. In this phase, SB behavior was also recorded by puma 4, and category C was not observed among the individuals.

In F2, the specimens exhibited IE behavior with all the environmental enrichment techniques provided, especially puma 1, and an increase in the expression of behaviors R, L, V and I, compared to Phase 1, was recorded. In addition, category C was observed in individuals 2 and 4. Puma 4 continued to exhibit SB behavior and puma 3 was aggressive towards other individuals.

In Phase 3, puma 4 stopped exhibiting C behavior and increased the frequency and duration of the expression of SB behavior. Compared to Phase 2, a decrease in the frequency of categories R, L, O, A, V, and I was observed in all individuals.

In F1, a higher frequency of inactive behaviors (90.35%) was observed in relation to active behaviors (9.65%). In F2, the values were altered, with an increase in active behaviors (36.45%) and a decrease in inactive behaviors (63.2%), compared to the behaviors expressed in F1. In F3, we observed an increase in the expression of inactive behavior R by puma 1 and 2 individuals (Table 2).

DISCUSSION

The environmental enrichment types aim to provide wild animals under human care with an interactive environment that is more similar to that found in nature. Improvements in the general structure of the enclosure, implementation of items such as burrows and branches, establishment of social groups or ways of arranging food are some examples of environmental enrichment (Beresca, 2014). One of the effects observed is the increase in activity levels of animals submitted to environmental enrichment (Celotti, 2001). In this report, a reduction in inactive behaviors was observed during the application of environmental enrichment. According to Prazeres *et al.* (2010), high percentages of inactive behaviors may indicate poor animal well-being; thus, the reduction of these behaviors observed in Phase 2 of the present study indicates a beneficial effect of the environmental enrichment techniques used.

Another goal of environmental enrichment is to assist in the conservation of endangered species by increasing the reproduction of individuals under human care (Beresca, 2014). In this study, pumas 4 and 2 exhibited reproductive behavior and interaction with other individuals during the enrichment phase. Similar results were observed by Lanier; Dewsbury (1976), who described estrous behavior in large felines under human care.

Stereotypy is a behavioral disorder characterized as repeated voluntary movements with no apparent function, such as pacing. Generally, stereotypic behaviors occur when the animal experiences an adverse and monotonous environment (Mason, 1991). Although puma 4 showed stereotypy in all three phases of the study, it was active, expressed natural behaviors, interacted with other individuals, and fed properly.

Aggressive behavior (Interaction), such as that presented by puma 3, has already been associated with stress due to territorial and hierarchical disputes (Orsini; Bondan, 2006). According to Krebs *et al.* (2018), the increase in aggressiveness

Table 2. Comparison of the relative frequency of active and inactive behaviors of puma (*Puma concolor*) specimens in Phase 1 (F1 - Pre-enrichment), Phase 2 (F2 - Application of Enrichments), and Phase 3 (F3 - Post-enrichments).

	Puma 1 (male)			Puma 2 (male)			Puma 3 (female)			Puma 4 (female)		
	F1 (%)	F2 (%)	F3 (%)	F1 (%)	F2 (%)	F3 (%)	F1 (%)	F2 (%)	F3 (%)	F1 (%)	F2 (%)	F3 (%)
SB	0	0	0	0	0	0	0	0	0	7.1	16.5	22.3
L	2.8	21.4	13.8	2.7	22.6	6.6	0.6	6	2.2	0.5	15.4	2.1
O	0.1	0	0	0.3	0	0	0	0	0	0	0	0
M	3.2	2.4	0.4	1	2.6	3.6	2	1.2	0.1	1	1.1	1.3
E	0	0.1	0.2	0.1	1.2	0.3	0.1	0.3	0.3	0.1	0.5	0
A	7.8	0.2	0	3.1	0	0	2.6	0	0	1.3	1.3	2.9
V	0.4	0	0	0	0.7	0.2	0	0	0	0.1	9.2	0.1
I	1.8	2.8	1.2	0.6	2.8	2.3	0	0.8	0.3	0.1	2.8	1.2
C	0	0	0	0	0	0	0	0	0	0	0.1	0
IE	0	15.5	0	0	4.8	0	0	4.8	0	0	9	0
H	20.5	3.1	0.1	32.3	0.8	4.1	50	26	39.5	0	3.6	35
R	64	54.9	84.3	60.3	64.6	83.1	44.5	60.5	57.7	89.9	40.7	35.2

Where: SB - stereotypic behavior; L - locomotion, O - Observation, M - Maintenance, E - Exploration, A - Alimentation, V - Vocalization, I - Interaction, C - Copulation, and IE - Interaction with Enrichment.

may be directly proportional to the aging process of individuals, who tend to become more aggressive and less interested in establishing social contact as they reach senility.

Although there are daily guided tours in the zoo, the individuals in this study did not show discomfort with the presence of visitors since the category observation was little recorded during the three phases. Another characteristic observed was the decrease in general behaviors in the beginning of the afternoon in the four individuals, with an increase in category R. This aspect was also observed by Campos *et al*. (2005) in a study with jaguars (*Panthera onca*), where the animals were more active in the morning. Jaguars have crepuscular or nocturnal habits, so observing these animals with an increase in the resting category (R) in the afternoon is normal for the behavior of the species (Adania *et al*., 2014). In addition, the presence of higher temperatures, commonly observed in the evening, is another factor that contributes to a reduction in the activity levels of the animals. Jaguars are more active in the cooler periods of the day (Campo *et al*., 2005).

CONCLUSION

Environmental enrichment is a strategy for the animal to seek its well-being through environmental modifications, as it increases the interaction of the animal with the enclosure and with other individuals, promotes the expression of behaviors, and reduces the inactivity of individuals.

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