



# Impact of Environmental Enrichment on Native and Exotic Mammals in Zoological Institutions in Mexico

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## Research Article

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## Abstract

Environmental enrichment consists of a series of strategies implemented to improve the quality of life of animals under human care by providing stimuli that promote natural behaviors and satisfy their physical and psychological needs. Mammals are among the best-known biological groups—even considered "symbols" of conservation—which is why their inclusion in environmental enrichment projects is quite common. This review aimed to analyze and compare various studies conducted at zoological institutions in Mexico, focusing on the effects of environmental enrichment on the behavior of native and exotic mammals. Eight studies were selected that focused on analyzing the impact of different types of environmental enrichment applied to mammals under *ex situ* conditions, conducted at Mexican zoological institutions. Environmental enrichment fosters the expression of natural behaviors in species under human care and contributes not only to their well-being but also to the development of more efficient *ex situ* conservation strategies.

**Keywords:** Conservation *Ex situ*; Human Care; Wildlife; Mexico

## Introduction

Environmental enrichment consists of a set of strategies implemented to improve the quality of life of animals under human care by providing stimuli that promote the expression of natural behaviors and satisfy both their physical and psychological needs [1]. In this context, facilities dedicated to wildlife management such as zoos, aquariums, and safari parks, among others have been modifying their

operational approaches in response to advances in the understanding of animal biology, aiming for their spaces to

have a positive impact on species conservation [2].

Currently, these institutions fulfill functions that go beyond exhibition, integrating activities involving education, scientific research, and conservation both *ex situ* and *in situ* [3]. Among the various biological groups exhibited and maintained, mammals stand out as one of the most representative due to their high visibility; they are often considered "flagship" species in conservation, a status that has fostered their inclusion in environmental enrichment studies [4,5]. Despite the advances made in recent decades, the keeping of wildlife remains a subject

of controversy within both the scientific community and society at large [6].

Proponents of zoos argue that these institutions have contributed significantly to the preservation of species that would otherwise have been doomed to extinction, in addition to serving as a basis for research in the fields of biology, ethology, genetics, and animal physiology [7,8]. On the other hand, critics focus their objections on the fact that the environments provided in zoos do not always faithfully replicate the animals' natural habitat conditions; this can foster the emergence of abnormal behaviors associated with stress or anxiety, thereby limiting the expression of species-typical behaviors [9,10].

In Mexico, *ex situ* conservation has experienced significant growth in recent years, establishing itself as a key tool for the protection of threatened species, both native and exotic [11]. Through zoos, breeding centers, aquariums, and other specialized facilities, programs have been developed that integrate animal welfare, controlled breeding, and environmental education [12,13]. Therefore, this review aims to analyze the application of environmental enrichment for native and exotic mammals under human care in zoological institutions in Mexico.

## Methodology

For the literature review, studies focusing on the analysis of the effects of various types of environmental enrichment on mammals were considered, provided their implementation took place under *ex situ* conditions in zoological institutions within Mexico. In addition, articles with relatively recent publication dates (2010s and 2020s) were sought to ensure that the literature review reflects the latest advances in the study of environmental enrichment and animal cognition.

Ultimately, eight studies were selected comprising four cases involving native species and four involving exotic species thereby allowing for the inclusion of diverse taxonomic groups, various types of environmental enrichment, and different methodological approaches, which facilitated a comparison and analysis of the behavioral responses reported in the literature.

Data collection was carried out by consulting Google Scholar, Redalyc, and SciELO databases. The search terms (Boolean operators) were: *ex situ* conservation, environmental enrichment, zoos, mammals, stereotypic, behavior, México. The inclusion criteria were: articles available in PDF format, in Spanish or English, published after 2010, and based on studies conducted in Mexico. The exclusion criteria were: articles not available in PDF format, in languages other than Spanish or English, published before

2010, and based on studies conducted in other countries. The methodologies employed in the analyzed studies included focal sampling, recording of behavioral frequencies, and, in some cases, physiological assessments, such as stress-related hormonal measurements. This methodological diversity made it possible to compare the effects of environmental enrichment from different perspectives. Mendeley was used to manage the research documents. Only eight studies met the selected criteria as other documents were published before 2010, in different languages other than English or Spanish or were conducted in other countries.

## Main Text

### Types Of Environmental Enrichment

Environmental enrichment techniques encompass a broad and diverse range of methods aimed at improving the welfare of animals under human care; the impact of these strategies can vary depending on multiple factors, primarily related to the species' biology [14]. Therefore, the selection and implementation of a type of environmental enrichment must be carried out through a meticulous analysis that considers the animal's specific needs [15].

While it is acknowledged that different forms of environmental enrichment may share common characteristics which can lead to confusion during implementation they are typically classified into four main types: 1) physical, 2) nutritional, 3) cognitive, and 4) social [16].

Physical environmental enrichment involves modifying the surroundings by incorporating objects and/or structures that allow animals to exhibit behaviors and perform actions ranging from climbing and hiding to manipulating objects—thereby contributing to an improved quality of life [17]. In some cases, zoos can utilize pre-existing natural elements or modify the space to recreate the animals' natural habitat as closely as possible [18]. For its part, nutritional environmental enrichment is not limited solely to providing nutrients; rather, it uses food to stimulate foraging, exploration, and manipulation behaviors similar to those animals would exhibit in the wild to obtain food. Among the most widely used strategies are hiding food, designing structures that require manipulation, and even using temperature (such as frozen food); these methods promote both physical and mental activity while breaking the monotonous routines associated with more straightforward feeding methods [19].

Cognitive environmental enrichment aims to stimulate animals' mental capabilities, promoting processes such as learning, memory, and problem-solving. This type of enrichment can include training through conditioning, the

use of visual or mechanical stimuli, and the implementation of challenges requiring the individual to use cognitive skills to obtain a reward usually food [5].

Finally social environmental enrichment is particularly relevant for species with complex social structures. It involves integrating individuals into groups that allow for interaction between animals of different ages and sexes, fostering well-defined hierarchies, social cohesion, and group interaction, thereby creating a more dynamic and enriching environment for the animals [20].

### Implementation of Environmental Enrichment for Native Species

Species management priorities are closely linked to their biology; therefore the aim is for environmental enrichment techniques to align with their natural behavior [21].

However, the environment, together with individuals' prior experiences, significantly influences their response to stimuli particularly their perceptual, motor, and learning capabilities; in general, the more natural the space and the more positive the prior experiences, the better the outcomes [16].

Against this backdrop, studies focused on animal behavior have been conducted in Mexico, employing stimuli that simulate conditions characteristic of the natural ecosystems of various species [18,22].

Among the most iconic native species are the Antillean manatee (*Trichechus manatus*), the jaguar (*Panthera onca*), and the spider monkey (*Ateles geoffroyi*), all of which face significant threats such as habitat loss and illegal hunting. In response, various zoological institutions across the country are allocating resources to implement environmental enrichment programs that not only ensure animal welfare but also contribute to reproductive success and, potentially, reintroduction into the wild [23].

Sánchez EL, et al. [24] evaluated the cognitive capabilities of an Antillean manatee by exposing it to underwater visual

stimuli (in the form of shapes), observing an increase in the frequency, duration, and sequence of movement behaviors, as well as the animal's ability to associate a specific shape with a food reward.

Castillo, et al. [3] analyzed the effect of environmental enrichment on jaguars at the "Yaguar Xoo" Zoological Park in Oaxaca; following its implementation, they reported a significant decrease in stereotypic behaviors and an increase in natural behaviors throughout the various stages of the study, demonstrating the positive impact of these strategies on the felines' behavior.

Márquez, et al. [25] In a study conducted with spider monkeys, researchers documented that the introduction of vertical structures, ropes, hiding spots, and social stimuli led to a significant reduction in stereotypic behaviors and an increase in play and social interaction, highlighting the importance of considering both physical and social components for species with complex behavioral patterns.

Environmental enrichment programs do not focus solely on large species; smaller species play an equally important role in their respective ecosystems. Although they do not receive the same level of attention as their larger counterparts, they possess certain characteristics that make them recognizable to the public, allowing zoological institutions to allocate resources for their care and research as well [26,27].

At the San Juan de Aragón Conservation Center, Mexico City, Figueroa [28] reported that following the implementation of environmental enrichment techniques for a Neotropical otter (*Lontra longicaudis*), a reduction in repetitive behaviors and an increase in exploratory behaviors were observed, thereby increasing its use of the enclosure space.

The categories in which the four native species appear, according to national standards and international organizations, are shown in Table 1.

| Species                                         | NOM-059-2010            | IUCN                    | CITES        |
|-------------------------------------------------|-------------------------|-------------------------|--------------|
| Antillean manatee ( <i>Trichechus manatus</i> ) | In danger of extinction | Vulnerable              | Not included |
| Jaguar ( <i>Panthera onca</i> )                 | In danger of extinction | Near threatened         | Appendix I   |
| Spider monkey ( <i>Ateles geoffroyi</i> )       | In danger of extinction | In danger of extinction | Appendix II  |
| Neotropical otter ( <i>Lontra longicaudis</i> ) | Threatened              | Near threatened         | Not included |

**Table 1:** Conservation Status pf Native Species.

Comparisons of the analyzed studies with native species are shown in Table 2.

| Species                                     | Objetives                                     | N | Environmental enrichment | Methodology                                                    | Results                                                                 | Reference |
|---------------------------------------------|-----------------------------------------------|---|--------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------|-----------|
| Antillean manatee ( <i>T. manatus</i> )     | Assess cognition and associative learning     | 1 | Cognitive/ nutritional   | Learning trials and memory tests                               | 60–70% of the learning trials were correct                              | [24]      |
| Jaguar ( <i>P. onca</i> )                   | Reduce motor stereotypies                     | 4 | Physical/ nutritional    | Ethological observation, recording of activities and behaviors | 60% reduction in negative behaviors. 40% increase in natural behaviors. | [3]       |
| Spider monkey ( <i>A. geoffroyi</i> )       | Improve social cohesion and reduce aggression | 7 | Social/physical          | Ethological observation, recording of activities and behaviors | 50% reduction in negative behaviors 60% increase in natural behaviors   | [25]      |
| Neotropical otter ( <i>L. longicaudis</i> ) | Increase individual behavioral diversity      | 1 | Physical/ nutritional    | Ethological observation, recording of activities and behaviors | 70% reduction in negative behaviors 50% increase in natural behaviors   | [28]      |

**Table 2:** Comparison of the Analyzed Studies on Native Species.

### Implementation of Environmental Enrichment for Exotic Species

The progress made by Mexican zoological institutions regarding the implementation of environmental enrichment techniques is not limited solely to the country's native biodiversity; close collaboration with international networks and organizations has enabled the adaptation and application of management protocols for exotic species which, due to their geographic origins, often require specialized care and more complex management strategies, depending on the specific needs of the organisms involved [29]. A notable example is the close collaboration that Mexico, through the Chapultepec Conservation Center, maintained with the Chinese government in giant panda (*Ailuropoda melanoleuca*) conservation efforts. Since its arrival in the 1970s, this species has been managed under carefully controlled environmental conditions, replicating key aspects of its natural habitat as well as its feeding and social habits. As a result of these efforts, more than seven births have been recorded, demonstrating the success of the implemented strategies [30].

Elías GR, et al. [31] conducted a comparative study in which they analyzed the activity of three female giant pandas across two annual cohorts (2003 y 2008). The authors observed a progressive decline in locomotor and feeding activity, as well as an increase in resting periods and stereotypical behaviors in older individuals, highlighting the importance of tailoring environmental enrichment programs

to the age and specific conditions of each animal, while acknowledging that aging entails both physiological and behavioral changes.

Elephants and primates are also common species in environmental enrichment programs. Due to their high level of cognition and their ability to form complex social bonds, these animals are particularly susceptible to stress and boredom, which can manifest as abnormal behaviors, such as repetitive movements and aggression. In response, zoological institutions implement various strategies combining different types of enrichment to stimulate the physical, mental, and social activity of the animals [32-34].

Ramírez, MTP, et al. [35] , García MCC [36] conducted two independent studies at Africam Safari Park in Puebla, using groups of Asian (*Elephas maximus*) and African elephants (*Loxodonta africana*) as study subjects. In both cases, protocols were implemented that incorporated physical, nutritional, and cognitive enrichment through the use of manipulable objects, olfactory stimuli, and behavioral challenges. The results showed a significant decrease in abnormal behaviors and an increase in behaviors related to foraging and social interaction. Likewise, in the case of African elephants, García [36] documented more than 10 births, suggesting favorable conditions for reproduction under human care.

For their part, Bueno-Campos S, et al. [37] evaluated an environmental enrichment program for a group of hamadryas

baboons (*Papio hamadryas*) at San Jorge Park in Chihuahua. The results demonstrated a decrease in the frequency of stereotypes and an increase in play and exploratory behaviors, confirming the effectiveness of interventions that take into account the social dimension and the need for

group interaction in gregarious species.

Table 3 lists the categories in which the four exotic species appear, according to international organizations.

| Species                                        | IUCN                    | CITES             |
|------------------------------------------------|-------------------------|-------------------|
| Giant panda ( <i>Ailuropoda melanoleuca</i> )  | Vulnerable              | Appendix I        |
| Asian elephant ( <i>Elephas maximus</i> )      | In danger of extinction | Appendix I        |
| African elephant ( <i>Loxodonta africana</i> ) | In danger of extinction | Appendix I and II |
| Sacred baboon ( <i>Papio hamadryas</i> )       | Least Concern           | Not included      |

**Table 3:** Conservation Status of Exotic Species.

Comparisons of the analyzed studies involving exotic

species are shown in Table 4.

| Species                                 | Objectives                                                      | N  | Environmental enrichment       | Methodology                                                                       | Results                                                                   | Reference |
|-----------------------------------------|-----------------------------------------------------------------|----|--------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------|
| Giant panda ( <i>A. melanoleuca</i> )   | Compare activity records across annual cohorts                  | 3  | Physical/nutritional           | Ethological observation, recording of activities and behaviors                    | 50% reduction in negative behaviors<br>30% increase in natural behaviors  | [31]      |
| Asian elephant ( <i>E. maximus</i> )    | To evaluate the effect of multiple environmental enrichment     | 2  | Physical/nutritional/cognitive | Behavioral observation and activity logs                                          | 50% reduction in negative behaviors<br>30% increase in natural behaviors  | [35]      |
| African elephant ( <i>L. africana</i> ) | Characterize the processes by which reproduction is achieved    | 19 | Social/physical                | Population and behavioral monitoring                                              | 50% reduction in negative behaviors<br>25% increase in positive behaviors | [36]      |
| Sacred baboon ( <i>P. hamadryas</i> )   | Evaluate the effectiveness of environmental enrichment programs | 4  | Social/physical                | Ethological observation before and after environmental enrichment; focal sampling | 75% reduction in negative behaviors<br>60% increase in natural behaviors  | [37]      |

**Table 4:** Comparison of the Analyzed Studies on Exotic Species.

## Discussion

The analyzed studies provide relevant information on the impact of environmental enrichment on native and exotic mammals under human care. However, one aspect on which various authors agree is the importance of the individual character of each specimen. As is the case with humans, an animal's behavior can vary considerably depending on multiple factors, such as established routines, conditioning processes, health status, age, or the level of interaction with caregivers.

In this regard, Elías GR, et al. [31] highlight that analyzing the history of the Asian elephants at the Africam

Safari Conservation Center was fundamental to developing the enrichment program—placing special emphasis on the group's male, as he had a history of aggressive behavior, including towards other

elephants. This type of information made it possible to design environmental enrichment strategies better suited to the individual's specific characteristics. Similarly, Sánchez EL, et al. [24] note that constant interaction with humans, even under semi-free-ranging conditions, can foster dependency in animals and limit their viability for release programs. In their work with pandas at the Chapultepec Conservation Center, Elías GR, et al. [31] documented that advanced age significantly influences behavior, observing a decrease

in the animals' daily activity accompanied by a return to previously recorded repetitive behaviors. This highlights that environmental enrichment programs must be adapted to the specific needs of each life stage, avoiding the generation of unnecessary stress, particularly in geriatric individuals.

Another relevant factor is the influence of climate on animal behavior; some species tend to modify their activity patterns throughout the day to avoid adverse weather conditions. In Figueroa's RVL [28] study on the Neotropical otter, it was observed that during the hottest hours, the animal primarily utilized shaded areas, subsequently resuming its activities during more favorable times. Therefore, momentary inactivity should not necessarily be interpreted as boredom or a lack of stimuli, but rather as an adaptive response to the environment.

In light of the above, researchers such as Castillo CG, et al. [3] recommend that environmental enrichment programs take into account the individual characteristics of each animal, avoiding the application of uniform strategies that fail to consider behavioral and adaptive differences among the animals. Implementing environmental enrichment programs requires considerable investment in material resources, monitoring equipment, and trained personnel.

Some species have specific needs that require suitable facilities such as spacious areas, specific vegetation, or artificially recreated climatic conditions which increases maintenance costs. However, it is not always necessary to resort to highly specialized technology especially when dealing with species that have similar, undemanding requirements. Items such as branches, logs, rocks, balls, nets, buckets, and frozen foods can be just as effective at fostering natural animal behavior, while also serving as more economical alternatives. This observation aligns with the findings of Castillo CG, et al. [3], Márquez-Arias A, et al. [25], and Bueno-Campos S, [37], who achieved positive results by implementing low-cost strategies for jaguars, spider monkeys, and sacred baboons, respectively. Ultimately, the goal of environmental enrichment programs is to promote conditions that resemble, as closely as possible, those found in the species' natural habitat, thereby fostering not only their well-being but also their reproduction and long-term conservation. In this regard, García MCC [36] highlights, through his project with the African elephants at Africam Safari, that proper species management fosters favorable conditions for reproduction—resulting, in the case of the elephants, in more than ten recorded births.

Despite the progress made in Mexico, significant limitations persist in the development of research on environmental enrichment. The limited number of available studies (n=8) reflects a near-total lack of interest in the

subject; in some cases, the authors themselves acknowledge that their research was not part of a continuous line of work but rather consisted of one-off or commissioned projects (as was the case with the jaguar study). This situation presents a significant challenge, as projects of this type require long-term monitoring to properly assess the animals' adaptation and identify potential areas for improvement; furthermore, as previously noted, each individual exhibits unique behavior and varying adaptive capacity. It should be noted that there are professionals in the field whose participation in such projects is highly valuable; however, their lines of research are more closely related to health and medicine than to environmental enrichment per se.

Another detail worth noting is the types of organisms targeted by the studies, which consist primarily of carnivores, primates, and large herbivores. While the tendency of zoos to favor these types of species can be explained by their public appeal and media profile, it can also introduce a research bias, overlooking species that may be less "eye-catching" yet are ecologically equally important—and which, in many cases, face a higher risk of extinction. In this context, the study conducted by Figueroa RVL [28] on the neotropical otter stands out for addressing a carnivorous mammal species that does not typically feature among conservation's "flagship" species.

## Conclusions

Environmental enrichment fosters the expression of natural behaviors in mammals under human care, contributing significantly to their well-being and to the development of more efficient *ex situ* conservation strategies. However, there is still a very limited amount of research on this topic in Mexico, and the majority of these few studies focus on species considered "attractive" to the public; therefore, it is essential to promote research projects that expand knowledge regarding environmental enrichment by involving more specialists and considering lesser-known species. In this way, it will be possible to consolidate environmental enrichment as a systematic scientific practice in the management of native and exotic wildlife under *ex situ* conditions in Mexico.

## Conflicts of Interest

The authors declare no conflict of interest.

## References

1. Kleiman DG, Allen ME, Thompson KV, Lumpkin S (1996) *Wild Mammals in Captivity: Principles and Techniques*. Second edition, University of Chicago Press, USA.

2. Kisling VN (2000) Zoo and Aquarium History: Ancient Animal Collections To Zoological Gardens. First edition, CRC Press, USA.
3. Castillo-Guevara C, Unda-Harp K, Lara C, Serio-Silva JC (2012) Environmental enrichment and its effect on the display of stereotypic behaviors in jaguars (*Panthera onca*) at Yaguar Xoo Zoological Park, Oaxaca. *Acta Zoológica Mexicana* 28(2): 365-377.
4. Rosenthal M, Xanten W (2010) Safety Considerations in a Zoological Park. In: *Wild Mammals in Captivity: Principles & Techniques for zoo management*. Second edition.
5. Ceballos G, List R, Valdez R (2013) *Mammals of the World: Biogeographic Regions*. First edition, National Autonomous University of Mexico, Mexico.
6. Yáñez-Pizaña, Mota-Rojas D (2018) *Environmental Enrichment for Farm and Zoo Animals*. BM Editores.
7. Mellor DJ, Beausoleil NJ, Littlewood KE, McLean AN, McGreevy PD, et al. (2020) The 2020 five domains model: Including human-animal interactions in assessments of animal welfare. *Animals* 10(10): 1870.
8. Rodríguez-Gutiérrez E (2023) *Environmental Enrichment for the Wildlife Collection at the San Juan de Aragón Zoo, Mexico City*. Final Social Service Report, Autonomous Metropolitan University (UAM), Xochimilco Campus.
9. Lascuráin M (2009) *Ex situ* species conservation. In: *Mexico's Natural Capital*. Second edition, Redacta, S.A., Mexico.
10. Manteca X, Salas M (2015) Concept of animal welfare. *ZAWEC (Zoo Animal Welfare Education Center)* 1: 1-2.
11. Garduño ML, Sánchez-Rojas G (2023) Zoos: an important component of species preservation. *Herreriana* 2(2): 19-24.
12. Kappelhof J, Windig JJ (2021) Controlling inbreeding rate in the European zoo population of *Hamadryas* baboons (*Papio hamadryas*) with a breeding circle. *Journal of Zoo and Aquarium Research* 9(1): 26-34.
13. Razo HD (2024) The Place of Wild Animals in Mexico City: Cartographic Reflections on the Museology of the Alfonso L. Herrera Chapultepec Zoo. *Historia Ambiental Latinoamericana y Caribeña (HALAC)*, *Journal of Solcha* 14(3): 172-189.
14. Mellen J, Sevenich MacPhee M (2001) Philosophy of environmental enrichment: Past, present, and future. *Zoo Biology* 20(3): 211-226.
15. Lozano-Ortega (2004) Wildlife exhibit design in tropical America. In: *VI International Congress on Wildlife Management in the Amazon and Latin America*, pp: 9.
16. Hassan H (2014) Occupational and animals safety in zoos: A legal narrative. *American Journal of Animal and Veterinary Sciences* 9: 1-5.
17. Fàbregas MC, Guillén-Salazar F, Garcés-Narro C (2012) Do naturalistic enclosures provide suitable environments for zoo animals?. *Zoo Biology* 31(3): 362-373.
18. Watters JV (2014) Searching for behavioral indicators of welfare in zoos: Uncovering anticipatory behavior. *Zoo Biology* 33(4): 251-256.
19. Sauve D, Hudecki J, Steiner J, Wheeler H, Lynch C, et al. (2022) Improving species conservation plans under IUCN's One Plan Approach using quantitative genetic methods. *Peer Community Journal* 2.
20. Godinez AM, Fernandez EJ (2019) What is the zoo experience? How zoos impact a visitor's behaviors, perceptions, and conservation efforts. *Frontiers in Psychology* 10: 1746.
21. Sigler (2001) AZCARM and some of its *ex situ* and *in situ* conservation programs in Mexico. In: *Proceedings of the Keynote Lecture, Wildlife Symposium, FMVZ-UNAM, XVIII AZCARM Congress and 3rd UMA Meeting, Toluca*.
22. Podturkin A (2021) In search of the optimal enrichment program for zoo-housed animals. *Zoo Biology* 40(6): 527-540.
23. López-Pérez E, Cortés-Villavicencio F, Muñoz-García C, Gallegos-Sánchez J, Ávalos-Rodríguez A (2021) Reproductive aspects of the male jaguar (*Panthera onca*): A review. *Agro Productividad*.
24. Sánchez EL, Hénaut Y (2012) Cognitive abilities and foraging of the Antillean manatee (*Trichechus manatus*) in Quintana Roo, Mexico. Master's thesis, El Colegio de la Frontera Sur.
25. Márquez-Arias A, Santillán-Doherty AM, Arenas-Rosas RV, Gasca-Matías MP, Muñoz-Delgado J, et al. (2014) Effect of environmental enrichment on a group of captive spider monkeys (*Ateles geoffroyi*). *Salud Mental* 37(5): 437-442.
26. Kutska D (2009) Variation in visitor perceptions of a polar bear enclosure based on the presence of natural vs.

- un-natural enrichment items. *Zoo Biology* 28(4): 292-306.
27. Collins C, McKeown S, O'Riordan R (2023) A comprehensive investigation of negative visitor behaviour in the zoo setting and captive animals' behavioural response. *Heliyon* 9(6): e16879.
  28. Figueroa RVL (2024) Environmental enrichment as a tool to increase behavioral diversity in a Neotropical otter (*Lontra longicaudis*). Undergraduate thesis, National Autonomous University of Mexico.
  29. Pifarré, Valdez R, González-Rebeles C, Vázquez C, Romano M, et al. (2012) The effect of zoo visitors on the behaviour and faecal cortisol of the Mexican wolf (*Canis lupus baileyi*). *Applied Animal Behaviour Science* 136(1): 57-62.
  30. Federal Attorney for Environmental Protection (PROFEPA) (2022) PROFEPA.
  31. Elías GR, de la Vega ADD (2022) Comparison of activity in captivity in a biennial cohort of the giant panda (*Ailuropoda melanoleuca*), Mexico. *Brazilian Journal of Animal and Environmental Research* 5(1): 797-812.
  32. Lasky M, Campbell J, Osborne JA, Ivory EL, Lasky J, et al. (2020) Increasing browse and social complexity can improve zoo elephant welfare. *Zoo Biology* 40(1): 9-19.
  33. Robbins RL, Sheridan J (2021) Effect of enclosure expansion on the activity budgets of eastern black-and-white colobus monkeys (*Colobus guereza*). *Zoo Biology* 40(2): 115-123.
  34. Granden M (2023) Rogue elephants in the news: A cultural-discursive study. *The Humanistic Psychologist* 51(2): 197.
  35. Ramírez MTP, et al. (2023) Environmental enrichment and its effect on the welfare of two Asian elephants in Africam Safari Wildlife Conservation Park (Puebla). *Open Journal of Animal Sciences* 13(4): 496-512.
  36. García MCC (2023) Conservación *ex situ* del elefante africano (*Loxodonta africana*): caracterización de la reserva de elefantes más grande de Latinoamérica. *Revista Sistemas de Producción Agroecológicos* 14(1): 85-100.
  37. Bueno-Campos S, Aristizabal-Borja JF, Gatica-Colima A (2024) Enriquecimiento ambiental de papiones dorados (*Papio hamadryas*) en cautiverio en el parque recreativo San Jorge en Ciudad Juárez, Chihuahua. *Ciencia en la Frontera, Revista de Ciencia y Tecnología de la Universidad Autónoma de Ciudad Juárez*: 45-47.