INFLUENCE OF ENVIRONMENTAL ENRICHMENT IN CAPTIVE CHIMPANZEES (*Pan troglodytes* spp.) AND GORILLAS (*Gorilla gorilla gorilla*): BEHAVIOR AND FAECAL CORTISOL LEVELS

Influencia del enriquecimiento ambiental de chimpancés (*Pan troglodytes* spp.) y gorilas (*Gorilla gorilla gorilla*) en cautividad: comportamiento y niveles de cortisol en heces

Félix Zaragoza [1]***, Miguel Ibáñez*** [*2]***, Blanca Mas*** [2]***, Santiago Laiglesia*** [2] ***y Bernadette Anzola*** [3]

[1] *Facultad de Veterinaria, Universidad Alfonso X el Sabio. Villanueva de la Cañada, 28691 Madrid.* [2]*Departamento de Producción Animal, Facultad de Veterinaria. Universidad Complutense de Madrid. Avda Puerta de Hierro s/n 28040 Madrid.*
[3]*Departamento de Producción Animal. Decanato de Ciencias Veterinarias. Universidad Centroccidental Lisandro Alvarado. Venezuela. * Corresponding author. Tel.: +34913943760. E-mail: mibanez@vet.ucm.es*

ABSTRACT

It is considered of significant importance to provide wild animals in captivity with environmental enrichment elements to improve their psychological and physiological well being, stimulating a higher activity and behavioral variety. This study evaluated the effect of different enrichment elements (explorative/manipulative, physical and feeding enrichment devices) on the behavior and physiology of two groups of great apes, gorillas (*Gorilla gorilla*) and chimpanzees (*Pan troglodytes*) at the Zoo-Aquarium of Madrid. The proposed prediction was that there would be a reduction of inactivity, anomalous and non-desired behavior, also on cortisol levels, as a result of the stimular improvements. The behaviors and cortisol faecal levels were compared between two different conditions: 1. previous phase without enrichment, 2. enrichment phase. The data analysis allowed measuring the efficiency of the enrichment, revealing that the frequency of inactivity and anomalous behaviors was significantly reduced in the enrichment phase. On the other hand, the frequency of exploratory-manipulative behavior increased in both species, whereas locomotors and feeding behaviors were reduced in gorillas but increased in chimpanzees. Also, the preferences of chimpanzees and gorillas for the diverse enrichments elements were different. In relation to the levels of cortisol, the results do not support the proposal for the initial hypothesis, both in the case of chimpanzees as in the case of gorillas, it had increased to such levels in the enrichment phase, the increase being significant just in the gorillas. The results on the behavioral parameters are consistent with the hypothesis because there is improvement induced by environmental enrichment.

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Key words: *Chimpazee, gorilla,* behavior, cortisol, environmental enrichment.

RESUMEN

Se considera de gran importancia proveer a los animales salvajes en cautividad de elementos para el enriquecimiento ambiental buscando mejorar su bienestar psicológico y fisiológico, estimulando así una mayor actividad y variedad del comportamiento. Este estudio evaluó el efecto de los diferentes elementos de enriquecimiento (dispositivos de tipo exploratorio/manipulativo, físico, y alimenticio) sobre el comportamiento y la fisiología de dos grupos de los grandes simios, los gorilas (*Gorilla gorilla*) y los chimpancés (*Pan troglodytes*), alojados en el Zoo-Aquarium de Madrid. La hipótesis planteada fue que habría una reducción de la inactividad, de las conductas anómalas y no deseadas, y de los niveles de cortisol, como consecuencia de las mejoras estimulares introducidas. Tanto el comportamiento como los niveles de cortisol en heces fueron comparados bajo dos diferentes condiciones: 1. fase previa sin enriquecimiento, 2. fase de enriquecimiento. El análisis de los datos permitió medir el efecto del enriquecimiento revelando que las frecuencias de la inactividad y de las conductas anómalas se redujeron significativamente en la fase de enriquecimiento. Por otro lado, la frecuencia de la conducta exploratoria-manipulatoria aumentó en ambas especies, mientras que las frecuencias de las conductas locomotrices y alimenticias se redujeron en los gorilas, pero aumentaron en los chimpancés. Además, las preferencias de los chimpancés y de los gorilas por los distintos elementos de enriquecimiento fueron diferentes. En relación con los niveles de cortisol, los resultados no apoyan la propuesta de la hipótesis inicial; tanto en el caso de los

chimpancés como en el caso de los gorilas, hubo un incremento de tales niveles en la fase de enriquecimiento, siendo significativo dicho aumento sólo en los gorilas. Los resultados sobre los parámetros de comportamiento son consistentes con la hipótesis planteada, debido a que se observaron mejorías inducidas por el enriquecimiento ambiental.

Palabras clave: *Chimpancé, gorila*, comportamiento, cortisol, enriquecimiento ambiental.

INTRODUCTION

Natural environment of living animal consists of a rich mixture of stimulant elements producing adequate responses in order to survive and breed. However, captivity drastically affects animal behavior [23, 34, 46]. Animal confining in a cage or pen reduces complexity and increases "predictability", so that several animal behavioral responses such as boredom or pathological behavior may arise [19, 34, 76]. Abnormal behavior is considered the consequence of stressing situations, stress implying physiological and psychological responses [12, 75]. Wild animal also suffer some stress as a result of stimular influence of natural environment. But in this case stress is rendered as a benefit, for stress allows wild animal to respond to danger situations in which organism activation is required [30, 63]. Nevertheless, captive animal under given conditions cannot face external stressing factors and when this situation persists over time, helplessness and frustration may arise [33].

Referring to animal welfare, separating physical aspects from physiological aspects becomes very difficult. When physiological needs are not covered it is highly probable that also psychological needs are not covered and *vice versa* [25, 26, 38]. A combination of physiological and behavioral measurements may provide an effective way of furthering the understanding of animal welfare [11, 67]. As physiological stress indicator, among others, in animals as well as in humans, cortisol levels have been used [8, 67, 77]. In highly stressing situations animal body reacts secreting great quantities of this substance, being its function to cope with the stress situation and repairing the damages that such a situation may have caused in the animal organism [60]. Nevertheless, stress and cortisol level relationship is not always direct, clear and simple; high stress level may increase, may decrease or may have no effect on cortisol levels [70].

Environmental enrichment is a concept which describes how the environments of captive animals can be changed for the benefit of the inhabitants. Behavioral opportunities that may arise or increase as a result of environmental enrichment can be appropriately described as behavioral enrichment [36, 65].

Enrichment systems are devised in order to reduce the effects of boredom and stress in captive animals and to reduce their abnormal behaviors [26, 36, 64, 66]. Well designed environmental enrichment programs must provide well being and life quality benefits through enhanced opportunities for the animal eliciting natural species-typical activities and promoting increased physical activity [2, 3]. Manipulating animal environment may increase daily activity and may also increase the time spent in species typical behavior that animal would show in the wild [80].

In the case of primate species, facilities enrichment requirements are even more important because of their notorious capacity of environment exploration, their intelligence characteristics and their rich behavioral repertoire [13, 72]. Thus, primates under impoverished husbandry conditions in captivity, lacking environment stimulation and showing inactivity routines frequently elicit abnormal and pathological behaviors reflecting boredom and stress in this situation [51, 61].

Therefore, zoological parks facilities for these animals require enrichment systems for the enhancement of their complex behavioral repertoire resulting in the improvement of their psychological well being and of their life quality [3, 6, 56]. Great apes (gorillas, chimpanzees, bonobos and orangutans) exhibit psychological and behavioral characteristics so that their housing in captivity results in mental health, social, maternal and sexual behavior alterations [37, 39]. Abnormal behavior, stress and boredom occurrence are generally regarded as factors indicating a restrictive or impoverished captivity environment and consequently related with enrichment systems requirement to suppress abnormal behavior and elicit great apes typical natural behavior [28]. Due to high cognitive and manipulative skills of these great apes, explorative behavior represents a significative proportion in great apes' behavioral repertoire [14]. Accordingly, enrichment systems considering these characteristics should achieve big success in generating a high response in manipulative and explorative behaviors.

As result of the enforcement of captive chimpanzee life quality improvement regulation (Chimpanzee Health Improvement, Maintenance and Protection Act) undersigned in December 2000, many chimpanzees have been transferred from environmental impoverished facilities to others provided with more natural and enrichment devices. Studies about the effects of several of these devices on the chimpanzee behavioral budget changes have shown a significative increase of desirable behavior (mutual grooming, play, tool use, social interaction) and significant decreases in abnormal behavior (coprophagy, hair pulling and ingestion, self mutilation, repetitive regurgitation and vomit ingestion, aggression, stereotyped movements such as swinging and self embracement) [28, 32]. Thus, the improvement of housing facilities conditions for great apes, such as chimpanzees and gorillas, has become a priority within the zoological parks enrichment programs [27, 28].

The aim of present research was to study the effects of environmental enrichment devices in captivity conditions of wild great apes species, common chimpanzee (*Pan troglodytes* spp.) and western plain gorilla (*Gorilla gorilla gorilla*). The main proposed objectives were as follows: a) to assess behav-

ioral changes associated with environmental enrichment devices introduction in their facilities, on the hypothesis that stimulation increase in captive animals enhances activity and reduces inactivity and abnormal behaviors, and b) evaluating if this environmental stimular change results in a decrease in faecal cortisol levels.

MATERIALS AND METHODS

Subjects and housing conditions

The study was performed on two groups of housed primates, one of chimpanzees and one of gorillas, in Zoo-Aquarium in Madrid. During experimental period, the chimpanzees group included 9 individually identifiable members: 2 adult males, 3 immature males and 4 adult females. Gorillas group included 1 adult male and 3 adult females.

Chimpanzee facility consisted of a wide outside zone (469.09 m^2), and 4 bedrooms (two of 9.4 m^2 and 11.4 m^2 two other). The outside zone comprised a large area with concrete floor and a low wall of 1 m high and 5 m. long as a visual barrier, also there was a structure of wood and metal (2 x 2 m) shaped platform with two height levels where chimpanzees climbed up and lay down, additionally, in the center of the enclosure was located on an artificial mound. Covering the entire top of the exhibit, to 2.5 m height above ground, there was a metallic structure, of 3 m high, that forms a network of bars for animal climbing. Surrounding the perimeter of the cage there were several walls of glass through which the public could see the animals.

Gorillas were housed indoors. This enclosure was 182 m^2, with two dorm rooms of 44 and 42 m^2. In this exhibit, there were several main artificial rock structures, forming columns and shelves on which the gorillas could climb on it. In the center of the facility was the artificial termite mound. It also stuck to the walls, there were two small areas of natural vegetation, with a purely ornamental, surrounded by an electrical fence to prevent the gorillas from eating plants. Natural light entered the enclosure through the windows located in the top of the main room. In this exhibition, as in chimpanzees, there were several glass walls to watch the animals.

Both gorillas and chimpanzees were fed at two times of day: early morning, immediately after removing them from their bedrooms, and in the evening, shortly after entering the bedroom. The diet consisted mainly of fruits and vegetables. Access to water was *ad libitum*.

Materials and procedures

The study was conducted in two phases: 1) control period without enrichment and 2) enrichment phase, lasting six weeks each. Data on primate's behavior were collected during these phases using an instantaneous scan sampling [1, 42] every ten minutes. Data compilation period extended from October 2004 to January 2005. All observations were conducted two hours and a half everyday, between 10:00 and 14:00 h. Data on activity and behavior of every animal, including individual use of enrichment devices, were taken in every sampling.

Categories of behaviors observed were as indicated in TABLE I. Enrichment devices used in phase 2 are presented in TABLE II; every week a new set of elements was introduced in alternative days, retiring the remainder of the previous one. The sixth enrichment device was different for each species: for the chimpanzees, last week enrichment device was of locomotive type, while for gorillas a manipulative-exploring device was used (TABLE II).

TABLE I
CATEGORIES OF BEHAVIOUR OBSERVED IN CAPTIVE CHIMPANZEES (Pan troglodytes spp.) AND GORILLAS (Gorilla gorilla gorilla)

Behaviour category	Behaviour elements
Inactivity	Sit, stand or lie
Feeding	Forage, eat and drink
Social	Allogrooming, play, display, chase, sexual, social conflicts
Locomotive	Brachiate, run, jump, walk
Explorative	Manipulative, tool use
Abnormal	Coprophagy and faecal manipulation, hair pulling and ingestion, repetitive regurgitation and vomit reingestion, stereotyped movements such as swinging and self embracement
Interaction with visitors	Every behaviour that primates performed to visitors

TABLE II
ENVIRONMENTAL ENRICHMENT DEVICES PROVIDED IN PRIMATE'S FACILITIES DURING SIX WEEKS. EACH GROUP WAS PRESENTED FOR THREE ALTERNATE DAYS IN A DIFFERENT WEEK

Enrichment devices	Description
1st week: Boxes	Cardboard closed boxes filled with wood chips, newspapers and magazines, clothes, plastic curtains, paper strips, dried grapefruits, dates, fruit and vegetables, peanuts and several seeds.
2nd week: Termite mound	Artificial termite mound filled with honey or yogurt. PVC tubes with honey and dried grapefruits inside.
3rd week: Balls	Rubber balls and balloons. Nautical defences.
4th week: Mirrors	90 x 40 cm mirrors.
5th week: Buoys	Nautical hollow buoys with holes and stuffed with dried grapefruits.
6th week (chimpanzees): Hanging fire hoses	Hanging hoses, ladders and hammocks made with fire hose. Pneumatic tyres and ropes.
6th week (gorillas): Fire hose ball	Fire hoses braided in the shape of a ball.

Faecal samples were collected at random in the facilities of both primates in order to analyse cortisol levels [12, 31]. Samples were collected from the daytime enclosure in the afternoon, once the primates had been transferred to their night quarters. Individual identity of each faecal sample was not determined. The number of fecal samples collected everyday was equal to the number of individuals in each enclosure (4 for gorillas and 9 for chimpanzees). Faecal samples were frozen (*NuAire* laboratory freezer: Mod. NU-9333E; air-cooled cascade refrigeration system; temperature range -20° to -86°C; electrical requirements 230V 50 Hz; Japan) and later assayed for cortisol at the Veterinary laboratories of the Universidad Complutense of Madrid. Subsequently, faecal cortisol levels recorded for both phases, control and enrichment, were compared.

Statistical analysis

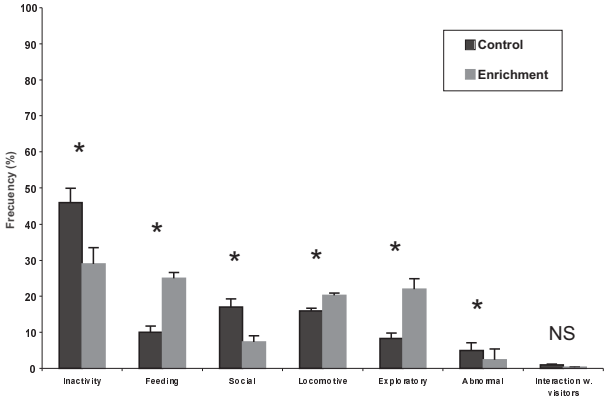
A total of 280 instantaneous scan-samplings for chimpanzee group and 250 for gorilla group, for each phase were analysed and data comparison between phases was accomplished. Statistical procedures used in this study were non parametrical tests (Wilcoxon, Friedman and Mann-Whitney tests), as the collected data did not satisfy equivalent parametrical test conditions [69, 81]. Depending on the problem to solve in each of the phases, repeated measures analysis were used: Wilcoxon, for comparing behavior and physiological data from control and enrichment phases and Friedman for enrichment devices comparison or Mann-Whitney independent samples tests in the case of sex and age effect assessing. Spearman correlation coefficient [69, 81] was used. And except other indications, *alfa* significance level used to reject the cero hypothesis was 5 per cent and contrasts were bilateral. Due to the small size of the gorilla group, pooled data were used for behavior data analysis in this case.

Of every study phase, 48 faecal samples were collected and analyzed of gorilla group and 108 faecal samples of chimpanzee group.

RESULTS AND DISCUSSION

Behavioral data

Chimpanzees. As shown in FIG. 1. enrichment was significant for chimpanzees' behavior when comparing previous control phase and enrichment phase. Group inactivity was reduced during enrichment phase (Wilcoxon matched pairs test, N=9, T=-2.666, P<0.05) and consequently, feeding behaviors (Wilcoxon matched pairs test, N=9, T=-2.666, P<0.05), locomotion (Wilcoxon matched pairs test, N=9, T=-2.192, P<0.05) and exploring activities (Wilcoxon matched pairs test, N=9, T=-2.666, P<0.05) showed increased frequencies in this phase. On the other hand, abnormal behaviors were significantly reduced during the enrichment phase (Wilcoxon matched pairs test, N=9, T=-2.547, P<0.05), the same as social behavior (Wilcoxon matched pairs test, N=9, T=-2.666, P<0.05), although there was no significant effect of enrichment on chimpanzees' interaction with visitors throughout the experimental study (Wilcoxon matched pairs test, N=9, T=-1.960, n.s.).



*significant difference. NS: not significant

FIGURE 1. FREQUENCY OF CHIMPANZEE BEHAVIOUR (AS PERCENTAGE) DURING CONTROL PHASE (PREVIOUS) AND ENRICHMENT PHASE.

When comparing frequency of use of the enrichment devices provided to chimpanzees, boxes were significantly more used than others (Friedman, n= 9; *df* = 5; ^{2} = 30. 858; P < 0.001) as shown in FIG. 2.

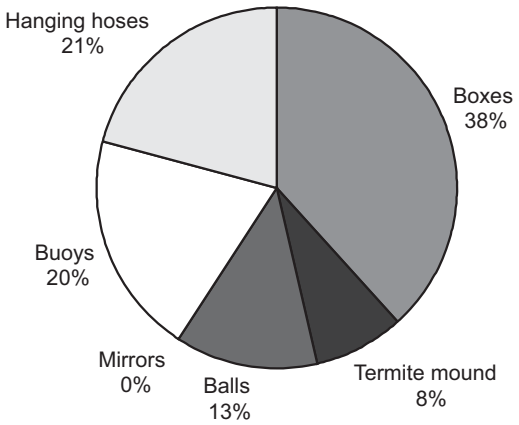


FIGURE 2. FREQUENCY OF USE OF CHIMPANZEE ENRICHMENT DEVICES IN PERCENTAGE.

There was no effect of sex or age on enrichment devices use: males (24.5%) *versus* females (19.8%) - Mann Whitney U, n =9; Z = -0.409; n.s. - or adults (17.6%) *versus* immature (32%) - Mann Whitney U, n=9; Z = -1.807; n.s. - as it was found.

Gorillas. Gorillas group in this study showed inactivity reduction during enrichment phase when compared with previous period (Wilcoxon matched pairs test, N=4, T=-14.546, P<0.05). Exploring behavior frequency was the only one higher in enrichment conditions (Wilcoxon matched pairs test, N=4, T=-8.354, P<0.05), whereas other animal behaviors, such as

feeding ((Wilcoxon matched pairs test, N=4, T=-15.133, P<0.05), social (Wilcoxon matched pairs test, N=4, T=-3.074, P<0.05), and locomotive (Wilcoxon matched pairs test, N=4, T=-4.143, P<0.05) were decreased. Likewise, abnormal behaviors were also reduced in the second phase (Wilcoxon matched pairs test, N=4, T=-3.879, P<0.05). Environmental enrichment did not have any significative effect on gorilla's interaction with visitors (Wilcoxon matched pairs test, N=4, T=-1.378, P<0.05) (FIG. 3).

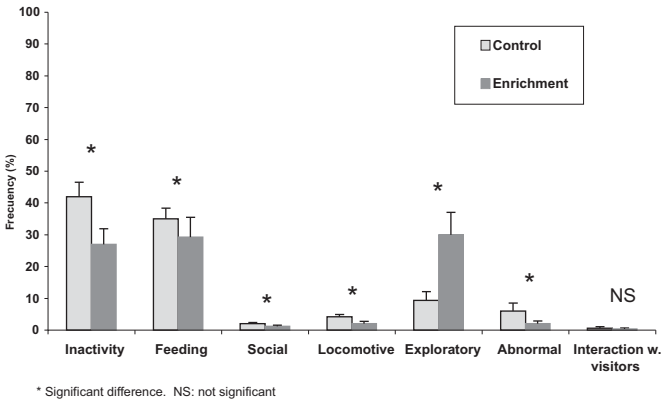


FIGURE 3. FREQUENCY OF GORILLA BEHAVIOUR (AS PERCENTAGE) DURING CONTROL PHASE AND ENRICHMENT PHASE.

As shown in FIG. 4, gorillas used mostly empty and food stuffed buoys amongst enrichment devices provided in experimental enrichment phase (Friedman, n=4; *df*=5; ^{2} = 15. 749; P < 0.05).

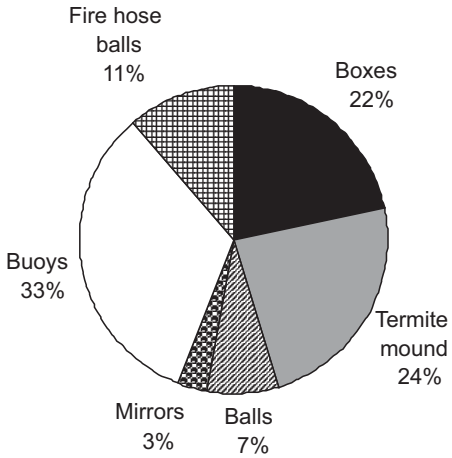


FIGURE 4. FREQUENCY OF USE OF GORILLAS' ENRICHMENT DEVICES IN PERCENTAGE.

Physiological data

Environmental enrichment had no significative effect on chimpanzees' faecal cortisol levels: 16.7 ng/mg (control or previous phase) *versus* 19 ng/mg (enrichment phase) (Wilcoxon test, n= 108, z = -0.220, n.s.) (FIG. 5).

Faecal cortisol levels of gorillas significantly increased in enrichment phase from 17 ng/mg in control or initial phase to 31 ng/mg (Wilcoxon tests, n =48, z= -2.093, P < 0.05) (FIG. 5).

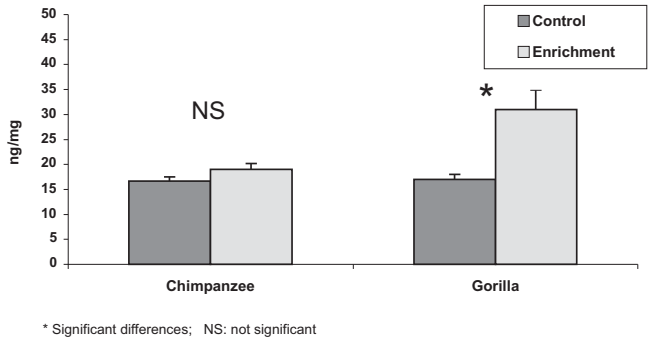


FIGURE 5. CORTISOL LEVELS IN BOTH PRIMATE SPECIES DURING CONTROL AND ENRICHMENT PHASES.

This research results showed that environmental enrichment proved effective in chimpanzees and gorillas. In both species inactivity and abnormal behavior were significantly reduced, as was the hypothesis initially proposed. This study confirms the idea that environmental enrichment has positive effects for species kept in captivity. The environmental enrichment brings the behavioral repertoire and activity budget of captive animals similar to that of wild co specifics. Inactivity, the same as boredom and apathy related behaviors are highly reduced when compared with captive animals without enrichment husbandry conditions. Moreover, enrichment devices provided result in abnormal and pathological behavior frequency reduction. Such abnormal behavior appearance is considered as a consequence of continuous apathy and boredom situation in daily life of confined animals. The individuals in this situation showed anxiety, *helplessness* and frustration, and need to alleviate these symptoms may be through pathological and stereotyped behaviors which could reduce the anxiety and, although pathologically, result in a escape of the stressing conditions. Considering that through enrichment the animals are neither inactive nor bored, but highly stimulated, abnormal behavior are changed into more natural and adapted behaviors.

Other very interesting result of this study is that both chimpanzee and gorilla exhibited higher explorative and manipulative behavior frequencies in the enrichment phase compared with control period. This enhances the relevance of enrichment on manipulative and exploring behavior for primates and particularly for great apes [52, 55].

Various and diverse studies and researches have been dedicated to intelligence and cognitive capacities of primates and specifically to that of great apes [4, 14, 59, 72]. Most of them have proved clearly enough the cognitive complexity of these animals demonstrated through their high cognitive abili-

ties and skills in manipulative and exploring tasks that require mental abstraction aptitudes, establishment of cause-effect relationship, mental images association and a high eye-hand coordination.

Apes often have to manipulate and process food to eat it, because sometimes the food is hidden, or difficult to access it, or just surrounded by thorns. For example, the mountain gorilla (*Gorilla gorilla berengei*) must perform complex manipulations to extract the edible parts of plants that they eat, to avoid being stuck with the thorns of the plant [13]; chimpanzees (*Pan troglodytes*) use stones to crack open nuts, sticks to extract honey from beehives and ant or termite from nests, and even use leaves, previously chewed, like a sponge to collect water from the cavities and inaccessible sites [17, 18, 72]. This manipulating capacity of objects requires some kind of mental representation and planning [17, 59, 72]. An example of this complex skill is the use of instruments held by great apes. The use of tools for obtains food or reward is a natural behavior in this species [4, 18, 59, 68, 71]. Chimpanzees modify and even make instruments with sticks and branches, which are then used to draw, drag, crush, reach down and dig up food or objects. Such behavior may suggest that chimpanzees plan activities in advance and are able to mentally represent the requirements of this task and high eye-hand psychomotor coordination [4, 18, 59, 68, 71]. Although less studied and documented than in the case of chimpanzees, gorillas and orangutans also use tools in solving certain problems, both in captivity and in the wild. In captivity both gorillas and orang-utans will use tools to obtain food, and several authors have described this behavior for gorillas [9, 10, 50, 78] and orangutans [47, 49]. In the wild, a documented case of an adult female gorilla who used a branch as a walking stick to test water deepness and to aid in her attempt to cross a pool of water [10]. Another case, observed by the same staff of researchers was the use of a trunk by another female as a stabilizing stick while dredging aquatic herbs towards her with her other hand [10]. Orangutans, in the wild, used sticks to dig seeds out of fruit, to poke into tree holes to obtain insects, or to scratch, or used leaves as napkins or as gloves to protect against spiny fruit [73, 74]. Even the great apes are able to make future plans to solve needs that can be found below. In a study on tool use by great apes, bonobos and orangutans selected, transported, and saved appropriate tools for future use [48]. Thus, it may approach to the conclusion that great apes are in need of environmental enrichment stimulating such abilities and behaviors.

The results of this study related to locomotive and feeding behaviors differed between species. While both behaviors were increased in environment enrichment phase for chimpanzees, both were decreased during environment enrichment for gorillas. This situation is easily understandable for locomotive behavior, for, while in the chimpanzee's facilities a large variety of locomotive enhancing enrichment devices – hanging hoses, ladders and hammocks made with fire-fighter hoses, pneumatic tires and ropes – were introduced, in the gorilla's none of them were used. Additionally, chimpanzee show more activity and dynamism in their locomotive behavior repertoire compared to that of gorilla [40, 57]. Regarding feeding behavior, other works have proved that chimpanzee show high response to feeding related enrichment devices [5, 7, 20, 41, 45], thus explaining our results.

Social behavior in both species decreased during the enrichment phase. It is plausible suposse that when animals do not get stimulation enough from the physical surroundings, they centre their attention in the social environment. Thus, primates, as eminently social animals, when confined in facilities with other individuals show very high social and interactivity behavior rates. Consequently, when in this research novelties and stimulating enrichment devices were introduced, primates temporarily abandoned their social activities in favor of behaviors directed to these new objects. This also confirms the relevance of housing primates in social groups of the same species.

The primates of this study showed different preferences for the various enrichment devices employed. While chimpanzees showed a significative preference for stuffed boxes, gorillas gave preference to the stuffed buoys, being both devices within the feeding enrichment category. Previous research extensively proved that feeding type enrichment is very successful with almost all animal species studied, for getting food is a priority task in survival strategy [62, 79, 80].

A very interesting fact, worth to note, is the different ways in both primate species responded to mirrors in their facilities: gorillas showed responses to their reflected image, socially interacting with that "other" individual, while chimpanzees completely ignored this stimulus and did not show any behavior or reaction to their own image. Many studies have researched great apes behavior in front of their reflected image, demonstrating that all of them show high response levels, and even exhibit self recognition in their reflected image [21, 24, 35, 53, 54].

In chimpanzee group, faecal cortisol level differences between control and enrichment phase were not significative. Nevertheless in gorillas group, faecal cortisol levels were significantly increased during enrichment phase. These results do not corroborate reduction of faecal cortisol level as a consequence of enrichment devices introduction in facilities, as the previous hypothesis stated. Thus, it should conclude that environmental enrichment, as that in the present study, has no diminishing effect on these animal physiological stress responses. Nonetheless this conclusion could not be quite certain. Research on differences in stress hormones levels relating to the state of welfare and husbandry conditions of the animal has produced very contradictory and diverse results [22, 30, 44, 58]. Adrenal response and high glucocorticoid levels are not always associated to pathological and chronic stress, for some non related to stress situation behaviors do also require these systems activation [43]. Likewise physiological stress response is under control of different cerebral structures related to other behavioral aspects. Thus, brain stress re-

sponse depends on the organism's previous experience, the behavioral response allowed by the context, and the predictability of the stressful events [15, 16].

The current study support, in general, the idea that environmental enrichment provide to captive primates stimulate a variety of behaviors and activities that are indicatives of a well being in the captivity conditions.

Although the usefulness of the enrichment devices proposed in this study have been demonstrated to work in a daily basis with great apes, the results show differences between the reactions of both species to environmental enrichment. And, in general, these results are consistent with the hypothesis of welfare improvements due to environmental enrichment in captivity.

CONCLUSIONS AND IMPLICATIONS

The results of this study showed that in both species, inactivity and abnormal behaviors were significantly reduced during the enrichment phase. Both chimpanzee and gorilla exhibited higher explorative and manipulative behavior frequencies in the enrichment phase compared with control period.

Results related to the levels of cortisol, did not corroborate the initial hypothesis: in both species, levels of cortisol were higher during the period of enrichment that during the control period, the difference was significant only in the group of gorillas.

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