Soriano et al., Res J Zool 2018, 1:2
DOI: 10.4172/RJZ.1000109

Research Journal of Zoology

Research Article

A SCITECHNOL JOURNAL

A Short-Term Macro and Microevaluation of an Environmental Enrichment Program in a Captive Pride of Southwest African Lions (*Panthera Leo Bleyenberghi*): Age-Class Differences

Soriano Al[1*], Fernández E[1], Vinyoles D[1] and Maté C[2]

[1]*Department of Animal Biology, Biology Faculty, Barcelona University, Diagonal Avenue 645, 08028, Barcelona, Spain*

[2]*Department of Animal Rights, Barcelona City Council, Avinyó Street 32, 08002, Barcelona, Spain*

[*]**Corresponding author**: Ana Isabel Soriano, Department of Animal Biology, Biology Faculty, Barcelona University, Diagonal Avenue 645, 08028, Barcelona, Spain, Tel: (034)687072662; E-mail: anaisabelsorianojimenez@gmail.com

Received date: April 23, 2018; **Accepted date**: June 10, 2018; **Published date**: June 20, 2018

Abstract

This study evaluates a feeding, occupational and sensorial environmental-enrichment programme in a pride of eight [2.6 (♂.♀)] Southwest African lions (*Panthera leo bleyenberghi*) housed at Barcelona Zoo. The evaluation was short-term due to the data was collected at the time in which the enrichment programme was introduced. In both study phases (baseline and enrichment macroevaluation), a total of 78 sessions of 30-min (19.5 h per animal) of observation were recorded to study the daily activity and the use of space. Sampling was multi-focal and data were collected using instantaneous 1 min-interval scans. The microevaluation of enrichment used an ad libitum recording and it studied the number of lions that interacted with enrichment devices in every 1-h 16 enrichment sessions. The aim was to determine whether there were differences for the two age classes: the adults (1.3) and the juveniles (1.3) in both phases. During the enrichment macroevaluation, both age classes showed an increased in 'not visible' and a decreased in 'vigilance'. Moreover, the adult lions showed an increase in 'inactivity' and a decreased in 'locomotion'; whereas the juvenile lions showed an increase in 'exploration' and a decreased in 'keeper interaction' and 'solitary play'. In relation to the space use, both age classes used exhibit zones differently during the enrichment programme. In addition, in both study phases, the juvenile lions used the exhibit more homogenously than adults. The microevaluation determined that all juvenile lions - but not all adults - interacted with all the enrichment devices provided.

Keywords: Adult; Juvenile; Daily activity; Enrichment programme; Southwest African lion; Space use

Introduction

Environmental enrichment is a management technique applied to animals in zoological institutions in order to improve their welfare. By studying the biology of animals in their natural habitats, environmental-enrichment techniques can be developed that aim to enhance species-typical behaviours in animals at zoological institutions [1].

Environmental enrichment is a relatively new concept that has developed quickly, especially in the last two decades. Nowadays, the evaluation of environmental enrichment is being investigated more thoroughly and developing more interest due to there are some previous enrichment studies which enrichment has apparently not worked [2]. The evaluation of environmental enrichment will make it possible to determine whether the enrichment is improving animal welfare, and to identify individual or group responses to the enrichment programme, the effect of the enrichment on the animal behaviour and the space use, the amount of time spent during each enrichment interaction, the number of interactions, or the number of animals interacting with the enrichment devices provided [3].

The methodology and terminology concerned with the evaluation of enrichment have also developed considerably. Thus, Soriano et al. [4] established three classifications related to the evaluation of enrichment studies. The first classification describes two concepts in relation to the time elapsed from the use of the enrichment device to the recording of the data. In short-term evaluation studies, the data are collected at the time during which the enrichment device is introduced to the animal (i.e. from 0 min to 24 h). In long-term evaluation studies, the data are collected starting 24 h after the application of the enrichment device. The device can be removed from the enclosure or it can remain. The second classification is related to the specificity of the studied variables and also has two classifications. In macro-evaluation studies, the impact of environmental enrichment on the general variables related to the daily activity patterns, abnormal behaviours, social interactions and use of space are evaluated. In micro-evaluation studies, some parameters related specifically to the enrichment devices; for example, latency, intensity, animal enrichment interaction time spent or number of animals interacting with the enrichment device. A third classification includes any combination of the four classifications described above, like the case of this study.

There are some studies in large felids which may be classified as short-term macro-evaluation of feeding enrichment: McPhee [5] studied nine cats and how carcass provision decreased off-exhibit stereotypic behaviours but with little impact on on-exhibit behaviours; Walters [6] evaluated the effect of four alternative feeding enrichment methods on the behaviour and the space use of a captive male tiger. In this case, there was an increase of behavioural and spatial diversity but not significant differences in abnormal behaviours; Ruskell et al. [7] used faecal glucocorticoid metabolites values and behavioural observations to quantify the effectiveness of bungee-carcass for two species of large cats. The neutral hormonal impact on the animals coupled with the behavioural changes (pacing decrease and walking increase in both cougars; 'other' behavioural categories decrease in tigers) indicates that this enrichment is successful without adding psychological stress; and Quirke and O' Riordan [8] who studied temporal feeding variation in eight cheetahs to determine how the level of effort in documenting the effect of enrichment is linked to how it is evaluated.

Two publications in captive large felids may be classified as short and long-term macroevaluation of feeding enrichment: Shepherdson et al. [9] studied in a first study, the presentation a fishing cat (*Felis*

viverrina) with live-fish and resulted in more activity, increased behavioural diversity, and greater enclosure utilization. Effects persisted for at least 48 h after presentation of live fish, and up to 8 days. In a second study, leopard cats (*F. bengalensis*) were fed multiple feedings of food hidden in small piles of brush. In this case, increased daily exploration and behavioural diversity and decrease pacing; (2) Charlton [10] studied three jaguars *P. Onca* interacting with a hessian sack filled with meat and hang at 3.5 m above the floor during three study phases: before enrichment, during enrichment, and after enrichment. During the enrichment programme, the activity levels and behaviours were closer to those of wild conspecifics and; (3) Bashaw et al. [11] studied two species of felids (African lions and Sumatran tigers) during three studied phases: before, during, and after enrichment. Live fish increased the variety and frequency of feeding behaviours meanwhile horse leg bones increased the frequency of these behaviours. Both enrichment reduced stereotypic behaviour and appeared to have sustained effects on behaviour lasting at least 2 days after presentation.

There is a publication in captive cheetahs (*Acinonyx jubatus*) which may be classified as short-term microevaluation of a feeding enrichment [12]. These authors studied 14 measures about feeding behaviour (e.g. time to approach food, duration of smelling, duration of licking, duration of looking away, number of chews/swallow or duration of molar use) comparing commercial and carcass diet. The carcass-fed animals showed an improvement of appetites, longer feeding bouts and a greater possessiveness of food.

There are three publications in different species of captive felids which may be classified as short and long-term macroevaluation of feeding, sensory, and occupational enrichment. Skibiel et al. [13] evaluated several types of enrichment in 6 different captive species. In this case, the proportion of time spent pacing significantly decreased during presentation of spices and frozen fish, but not with the addition of bones. Effects on enrichment items on activity were not sustained seven days after removal. Van Metter et al. [14] evaluated a feeding, sensorial, and occupational enrichment programme in four tigers (*P. tigris sumatrae*) and two lions (*P. leo leo*). Enrichment utilizing stimulus objects was successful in increasing behavioural diversity of lion and tiger subjects. Moreover, the subjects did not habituate to the stimulus objects during the 10 weeks of the study. Quirke and O'Riordan [15] recommend the use of temporal feeding variation, spatial feeding variation and olfactory enrichment, introduced to nine cheetahs on a random schedule.

In terms related to short-term macro and microevaluation of sensory enrichment: Markowitz et al. [16] study the effectiveness of acoustic enrichment for a captive African leopard (*P. pardus*) where the general activity increased and stereotypic behaviour decreased during apparatus utilization. Damasceno et al. [17] demonstrated the enrichment had similar effects, in terms of enrichment-directed behavior and no evidence of habituation for any of the three sensory enrichments.

The study of Powell [18] in felids is the only until now that had a distinction between African lion cubs and adults in terms of enrichment evaluation. This study may be classified as short-term macroevaluation including three types of enrichment items (feeding, sensorial, and occupational) on four captive African lions (*P. leo*). All enrichment items produced positive changes on behaviour and an increasing of space use. In this case, the enrichment programme had a roughly equal effect on the behaviour of the adults and cubs.

In terms related to the enrichment effect on the age-class differences, the main idea is thinking that the juvenile animals tend to interact with enrichment items more than adults due to the young animals have an increased rates of exploration and play [19]. This statement was ratified by: 1) Glickman and Sroges [20] who found that a sample of captive mammal sub adults tends to be more reactive to novel objects than adult members of the same species; 2) Jaman and Huffman [21] examined the effect of environmental enrichment on age class differences in feeding behaviour of Japanese macaques (*Macaca fuscata*). Immatures living in an enriched enclosure utilized significantly more food items and spent more time in feeding than adults; and 3) Eskelinen et al. [22] observed that bottlenose dolphin (*Tursiops truncatus*) calves participated significantly more than adults or sub-adults across three enrichment classes (social with human, feeding, and occupational).

A short-term macro and microevaluation of a feeding, occupational and sensorial environmental-enrichment programme was applied in a pride of Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain. The enrichment macroevaluation studied the daily activity and use of space of the pride meanwhile the enrichment microevaluation studied the number of animals that interacted with the enrichment device in order to determine whether there were age-class differences (i.e. the adults and the juveniles) between baseline and enrichment phases.

Material and Methods

Subjects

The pride contains eight Southwest African lions (*P. l. bleyenberghi*) in the lion exhibit at Barcelona Zoo. All the subjects were zoo bred and reared by their mothers (Table 1).

Name	Sex	Date of Birth	Place of Birth	Date of Arrival at the Zoo	Parents
Adults					
Roque	♂	Jul 1993	unknown	Nov 1993	unknown
Borracha	♀	Oct 1994	unknown	Nov 1995	unknown
Nena	♀	Jul 1997	Barcelona Zoo	-	unknown
Vieja	♀	Aug 1992	unknown	Nov 1993	unknown
Juveniles					

Lutecio	♂	Jul 2004	Barcelona Zoo	-	Roque/unknown
Runrún	♀	Jul 2004	Barcelona Zoo	-	Roque/unknown
Nima	♀	Aug 2004	Barcelona Zoo	-	Roque/unknown
Zala	♀	Aug 2004	Barcelona Zoo	-	Roque/unknown

Table 1: Demographic information about the Southwest African lions (*Panthera leo bleyenberghi*) studied at Barcelona Zoo, Spain.

Exhibit location

During the observations, the Southwest African lions pride was housed together in a concrete moat-style semi-naturalized exhibit. The inside area is c. 150 m^2, off view and located below the outside area in the upper zone. There are four concrete and bar dens, each with an automatic drinking trough. The outside area is c. 1090 m^2 and divided into three different levels: viewpoint or upper zone, cove or medium zone and moat or lower zone. The viewpoint presents several concrete steps, some of which are connected to the cove, and a palm tree. The cove presents sand terraces, a cove area, large overturned logs and an automatic drinking trough. The cove is 363 m^2 without water and has a smooth concrete substrate. In the moat there is a tunnel that is used by the lions to move around the cove and the various moat areas (Figure 1).

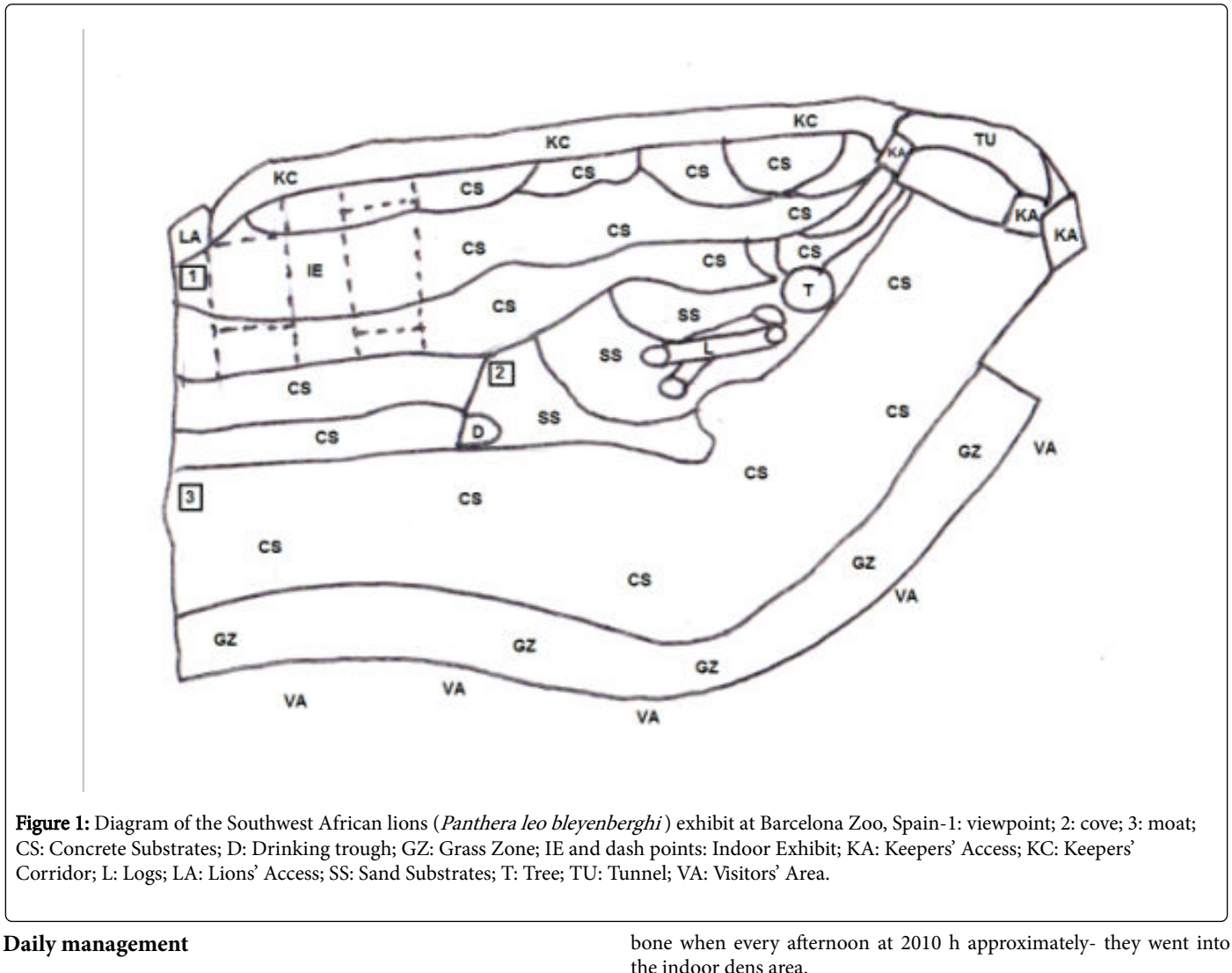

Figure 1: Diagram of the Southwest African lions (*Panthera leo bleyenberghi*) exhibit at Barcelona Zoo, Spain-1: viewpoint; 2: cove; 3: moat; CS: Concrete Substrates; D: Drinking trough; GZ: Grass Zone; IE and dash points: Indoor Exhibit; KA: Keepers' Access; KC: Keepers' Corridor; L: Logs; LA: Lions' Access; SS: Sand Substrates; T: Tree; TU: Tunnel; VA: Visitors' Area.

Daily management

During two study phases - baseline phase (BP) and enrichment phase (EP) - the animals remained in the outdoor facilities from 0800 h to 2000 h. Each lion was provided with 2.5 kg of horsemeat with bone when every afternoon at 2010 h approximately- they went into the indoor dens area.

Recording methods

In both phases during macroevaluation, the observation sessions lasted 15 min and were collected by the same observer. Sampling was multi-focal and data were collected using instantaneous 1 min-interval scans [23]. Using this method, the adult lions were simultaneously observed in even min whereas the juvenile lions were simultaneously observed in odd min. A total of 78 sessions with 19.5 h of observation were recorded in each phase of study. The data corresponding to the BP were collected in May 2005 whereas data for EP were collected in July 2005, in both cases from 1100 h to 1800 h.

Behaviour	Description
Exploration	The subject is inspecting an area or object, visually, nosily, tastily or listens. It also includes manipulation with the claws
Feeding	The animal is ingesting food or drink
Inactivity	The animal remains immobile, sitting or lying down, with his eyes open or closed and muscles relaxed
Keeper interaction	The lion is sitting or lying down meanwhile looks after zoo keepers
Locomotion	An animal is moving around the facilities (excluding activities forming part of aggressive interactions, play or stereotyped behaviour)
Maintenance	The subject is grooming or scratching itself with its tongue and/or claws. This behaviour also includes: defecating, urinating, scratching, rubbing or scent marking the surface or furniture from the exhibit
Social interaction	Includes behaviour involving two or more interaction individuals, which may be aggressive, parental, sexual or recreational
Solitary play	Includes all vigorous and exaggerated movements, whether or not involving an object but without relations with other individuals
Vigilance	The animal is alert, with his head up, ears pricked and eyes open, standing or lying down
Not visible	The subject or his behaviour is out of the observer's sight

Table 2: Ethogram of the different behaviours observed in Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain.

The records were balanced over three periods of the day (morning: 1100 h-1300 h; midday: 1300 h-1500 h; afternoon: 1500 h-1800 h). Several daily activity patterns were documented (Table 2). In order to study the use of space, the exhibit was homogeneously divided into seven zones and the tunnel (Figure 2).

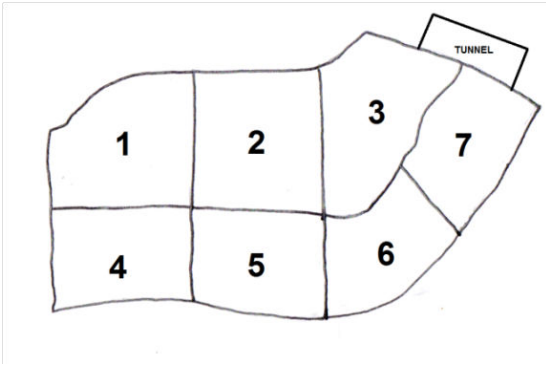

Figure 2: Layout of the Southwest African lions (*Panthera leo bleyenberghi*) enclosure with the seven homogeneous zones identified for a study into the use of space by the adults and juveniles at Barcelona Zoo, Spain.

Enrichment-programme sessions

The sixteen EP sessions were categorized as feeding; occupational or sensory (Table 3). The lions did not have experience with these enrichment items prior to this study. The enrichment micro-evaluation was carried out in July 2005, from Tuesday to Friday at 0800 h when the animals came out from their dens into the outdoor facilities. During these sessions the observer spent 1 h carrying out ad libitum recording (0800 h-0900 h) to determine the ratio of the adult and the juvenile lions that interacted with enrichment devices.

Enrichment		
Day	**Device**	**Category**
5	8 bone dog toys	F
6	8 frozen blocks of chicken stock	F
7	2 cans of wet dog food	F
8	8 fresh watermelons	F
12	1 jar of drying mint scattered	S
13	8 cardboard boxes with 10 grasshoppers	F
14	8 whole died rabbits	F
15	8 frozen blocks with slices of horsemeat	F
19	8 camel locks of hair scattered	S
20	1 spray of men deodorant	S
21	8 frozen watermelons	F
22	2 cans of pepper pâté spreader in toasts	F
26	8 cardboard boxes with zebra excrements	S
27	4 tyres tied up with a fixing chain	O
28	8 handfuls of dog chow	F

29	1 jar of garlic powder scattered	S

Table 3: Enrichment-device schedule for a pride of Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain: enrichment categories-F: Feeding; O: Occupational; S: Sensory.

Analysis

The Statistical Package for the Social Sciences version 21.0 for Windows (SPSS Inc., Chicago, IL 60606, USA) was used to analyse data.

The categorical data for the daily activity pattern and the use of space were analysed through contingency tables, adjusted residual and Pearson's X^2test. Adjusted residuals (z) had an absolute value of 1.96 for a normal distribution, assuming that the significance level is 0.05 [24]. Moreover, this statistical test permitted to determine exactly which categories of the daily activity pattern and the use of space presented statistically significant differences. Pearson X^2 was used to determine whether there were statistically significant differences in the two study phases for the two dependent variables in relation to the age class.

The Spread of Participation Index (SPI) was used to analyse the effect of enrichment programme in the use of the space in both age classes. A value of zero (0) indicated a homogeneous use of space while a value of one (1) indicated a use totally heterogeneous [25,9,26,4].

Results

Macro-evaluation

During the EP there was a decrease in 'vigilance' and increase in 'not visible' in both age classes (Figure 3).

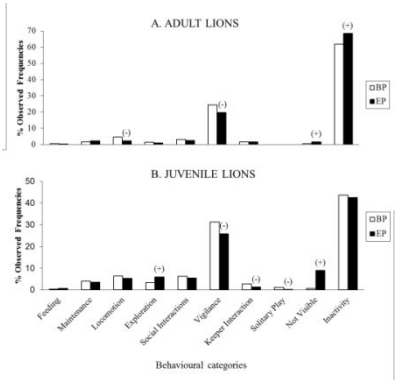

Figure 3: Daily activity pattern in the Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain-A: Adults; B: Juveniles.

The daily activity pattern for adults showed statistically significant differences between two phases of study (X^2=50.2, df=8, P<0.00**). During the EP, adult lions showed a significant increase in 'inactivity' and a decrease in 'locomotion'. No changes were observed in 'feeding', 'maintenance', 'exploration', 'social interactions' and 'keeper interaction'. Moreover, 'solitary play' was never observed in adult lions, neither in the BP nor the EP (Figure 3a and Table 4).

The daily activity pattern for the juveniles shows statistically significant differences between two phases of study (X^2=210.3, df=9, P<0.00**). During the EP, the juvenile lions showed a significantly increase in 'exploration', and a decrease in the 'keeper interaction' and 'solitary play' categories. No changes were observed in 'feeding', 'maintenance', 'locomotion', 'social interactions' and 'inactivity' (Figure 3b and Table 4).

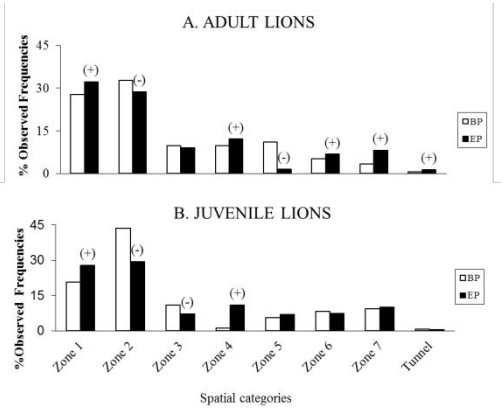

Figure 4: Use of space in the Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain-A: Adults; B: Juveniles.

In relation to the use of space, during the EP both age classes significantly decreased the use of zone 2, and increased the use of zone 1 and zone 4 (Figure 4).

	Adults	Juveniles
Feeding	0.5	1.5
Maintenance	1.3	0.9
Locomotion	3.9**	1.5
Exploration	1.5	8.7**
Social interactions	1.4	1.7
Vigilance	3.8**	4.0**
Keeper interaction	0.1	3.4**
Solitary play	-	1.5
Not visible	3.3**	12.7**
Inactivity	4.5**	0.6

Table 4: Adjusted residuals in absolute value for each behavioural category of the daily activity pattern for a pride of Southwest African lions (*Panthera leo bleyenberghi*) at Barcelona Zoo, Spain: ** statistical significant difference /z/ >1.96, where the z score is a measure of standard deviation of mean.

Moreover, during EP only adult lions significantly increased the use of zone 6, zone 7 and the tunnel, whereas the use of zone 5 decreased (X^2=231.1, df=7, P<0.00**). However, no change was shown in the use of zone 3 (Figure 4a and Table 5).

In the case of the juveniles, there was a decrease in the use of zone 3 (X^2=281.0, df=7, P<0.00**), whereas no statistically significant differences were found in the use of zone 5, zone 6, zone 7 and the tunnel (Figure 4b and Table 5) during EP.

	Adults	Juveniles
Zone 1	3.2**	5.4**
Zone 2	2.9**	9.7**
Zone 3	0.7	4.4**
Zone 4	2.4**	13.7**
Zone 5	12.9**	1.8
Zone 6	2.4**	1.0
Zone 7	6.9**	0.8
Tunnel	2.5**	0.4

Table 5: Adjusted residuals in absolute value for each spatial category of the use of space for a pride of Southwest African lions *Panthera leo bleyenberghi* at Barcelona Zoo, Spain: ** statistical significant difference /z/ >1.96, where the z score is a measure of standard deviation of mean.

The SPI index results for the adult lions were 0.55 in the BP and 0.45 in the EP, while for the juveniles the results were 0.45 in the BP and 0.37 in the EP.

Micro-evaluation

Table 6 indicates the ratio of lions that interacted with every enrichment device offered in relation with their age classes. All juveniles (but not all adults) interacted with all enrichment devices. None of adult lions interacted with the scattered dry mint, scattered locks of camel hair and the scattered garlic powder.

Discussion

In this study, the 'feeding' category showed no variation in either age classes or study periods like the results observed in McPhee [5] who studied the provision of whole carcasses as a feeding enrichment and found that not all cats responded with increased feeding activity. However, the following publications observed an increase of feeding during enrichment: (1) Bond and Lindburg [12] found as carcass-fed cheetahs showed improved appetites, longer feeding bouts and greater possessiveness of food; (2) Powell [18] found an increase of lick/gnaw with the implementation of a fishsicle in adults and cubs of an African lion pride; (3) Charlton [10] observed that the provision of an environmental feeding-enrichment device increased the total time spent feeding in three jaguars; and (4) Bashaw et al. [11] also determined that the presentation of live fish to African lions increased the variety and frequency of feeding behaviours.

Ratio of Animals Interacting		
Enrichment Device	**Adults**	**Juveniles**
Bone dog toys	4/4	4/4
Frozen blocks of chicken stock	3/4	4/4
Cans of wet dog food	4/4	4/4
Fresh watermelons	2/4	4/4
Jar of drying mint scattered	0/4	4/4
Cardboard boxes with ten (10) grasshoppers	4/4	4/4
Whole died rabbits	4/4	4/4
Frozen blocks with slices of horsemeat	4/4	4/4
Camel locks of hair scattered	0/4	4/4
Spray of men deodorant	4/4	4/4
Frozen watermelons	0/4	4/4
Cans of pepper pâté spreader in toasts	3/4	4/4
Cardboard boxes with zebra excrements	2/4	4/4
Tyres tied up with a fixing chain	2/4	4/4
Handfuls of dog chow	3/4	4/4
Jar of garlic powder scattered	0/4	4/4

Table 6: Ratio of Southwest African lions (*Panthera leo bleyenberghi*) in each age class at Barcelona Zoo, Spain, that interacted with the different enrichment devices provided during EP micro-evaluation.

The pride of African lions in this study had no significant variation in the 'maintenance' behaviour observed, either in age classes or the two study phases like the results obtained by: (1) Powell [18] did not find significant differences in face rub and back roll in frozen balls of ice containing fish, scents or hanging logs in adult and cub African lions and (2) Charlton [10] who observed no variation in grooming behaviour in three Jaguars. However Walters [6] reported that the time spent grooming increased significantly with the different presentation of food items.

During this study, the 'social interactions' of the adult and juvenile lions did not show any variation during the enrichment phase. This may be because the management in this did not allow them to exhibit social species-typical behaviours, such as hunting for prey, searching for a mate or breeding behaviours.

There were two behaviours that had the same result in both age classes during the enrichment phase; that is, a decrease in 'vigilance' and an increase in 'not visible'. The decrease in 'vigilance' most probably denoted that the attention of the lions was redirected towards the enrichment devices and that the animals were more entertained and did not pay attention to routine external matters. On the contrary, Powell [18] did not observe variations in alert behaviour for lion adults and cubs during the provision of any enrichment device.

The results of the not visible reported here are in accord with: (1) McPhee [5] that studied the 'hiding on exhibit' behaviour in large felids increased significantly during three trials of carcass provision and (2) Walters [6] also observed that a male tiger was 'out of sight' on a greater number of occasions during the week when multiple enriched feeding was provided. However, Bashaw et al. [11] did not find significant differences in 'not visible' behaviour in large felids during an enrichment programme. May be the animals decide to go into not visible places in order to avoid negative external stimulus like the visitors or climatic conditions. It is obviously necessary a balance

between animal necessity to privacy and zoo visitors' expectations. Therefore, it is necessary to design new enclosures with privacy places but with visibility for the visitors using plants, rocks, nets, etc. in combination with cameras and monitors of new technology in order to see the animals in any condition (extreme climatic conditions, breeding season or indoor enclosures) [2].

During the EP, the 'locomotion' decreased significantly in the adult lions but it did not vary in the juvenile lions. On the contrary, follow studies observed an increase in 'locomotion' during the implementation of enrichment: (1) Powell [18] observed a significantly increase in the 'stand/locomote' category in the adults and the cubs when frozen balls of ice containing fish and various scents where presented in the enclosure; (2) Charlton [10] denoted a significant increase in the 'move' category in a jaguar; and (3) Walters [6] observed a significant increase in 'locomotion' in a male tiger.

In the case of the 'exploration' behavioural category, this did not vary for adults during the EP but it increased in juveniles during the same phase. Powell [18] also observed a significant increase of 'paw manipulation', which in the study reported here is included in 'exploration' category, in adult lions and cubs when a fishsicle, various scents and hanging logs were provided.

'Keeper interaction' did not vary for adults but it decreased in the juveniles during EP. When the juvenile lions were interacting with enrichment items may be they were less susceptible to look out keepers' movements because they consider enrichment more interesting. The latest and interesting studies in relation to keepers try to evaluate the effect of keepers' personality on felid welfare [27,28].

The 'solitary play' behavioural category was not observed in adult lions in either phase; however, this behaviour decreased in the juveniles during the EP may be due to that the juvenile lions preferred interacting with the enrichment items. It is also important to consider the function of play during the juvenile period because this behaviour is widely assumed to be a juvenile activity, crucially involved in the development of adult behavioural skills and exerting major beneficial effects on behaviours required later in ontogeny [29]. Schaller [30] determined that the type of play demonstrated by lions depends on the state of development: cubs are more playful than sub-adult or adult lions, coinciding with the results observed in the adults in this study.

When visitors walk around the facilities for lions in zoological institutions there is a general feeling that the low activity that these felids show is due to lack of space and boredom [31]. What not all visitors know, however, is that one of the natural behavioural characteristics of lions is inactivity. In the wild, lions remain inactive for 20 h to 21 h a day; spend 2 h travelling across their territory and 40-50 min eating, provided that hunting has gone well although they can have several days without eating [30]. For this reason, it is important to avoid a possible stress by over increasing lions' activity through enrichment programmes and to work hardly in the educational programmes for zoo visitors [32].

The final behavioural category in this study was 'inactivity', which increased in adult lions but did not vary in the juveniles during the EP. Margulis et al. [33] determined a relationship between inactivity and season (i.e. spring: 85% inactivity; summer: 90% inactivity) in lions. Further studies would be necessary to determine the influence of temperature on the daily activity pattern and use of space for lions in zoological institutions. It is also important to take into account whether the provision of environmental enrichment causes stress to those animals that generally demonstrate high percentages of rest or inactivity, thereby unbalancing their species-typical behaviour ratio. In this case, it is important to distinguish between the time spent resting as a naturally predominant state, and apathy as a result of boredom and an inadequate environment. Perhaps the enrichment programmes implemented for animals such as lions, should aim to reduce undesirable behaviours (e.g. stereotypies or aggression) rather than increasing activity. Moreover, the study reported here corroborates the enrichment-evaluation strategies found in the literature; that is, large felids benefit from the implementation of environmental-enrichment programmes although they spend the most amount of their time resting. Various publications have concluded that there is no significant variation in inactivity during the implementation of a feeding-enrichment programme; for example, Powell [18] for African lion adults or cubs, McPhee [5] with large felids, Charlton [10] with jaguars, and Walters [6] with a male tiger. It would be interesting to understand whether environmental enrichment with the aim of increasing activity in animals that have naturally high levels of species-typical inactivity, would really improve the welfare of these subjects. This point has implication of for visitors to zoological institutions who become frustrated when they do not see the animals during their visit. Good signage can be used to educate the public about the natural behaviours of such species and alleviate these problems [34].

In relation to the use of space, the results of this study indicate that during the enrichment phase in both age classes, use of space was fairly consistent and comparable with three studies: (a) a male tiger whose enclosure utilization was greatest on the days which food presentation was varied [6]; (b) a fishing cat with live-fish that showed greater enclosure utilization [9]; and (c) Powell [18] determined the adult SPI did not show significant changes between the BP and EP, meanwhile the use of space in the juveniles was more homogeneous during EP.

In relation to the environmental-enrichment micro-evaluation, the results of this study concluded that all juveniles but not adults interacted with all enrichment devices. There are also other studies in some species of mammals [20], Japanese macaques [21], and bottlenose dolphins [22] whose results showed that the juveniles tend to interact with enrichment devices more than adults.

In this study, none of the adult lions interacted with scents (i.e. mint and garlic powder). It seems to be that sensory enrichment in adults has less effect than feeding ones. These results had also been observed in: 1) Powell [18] observed that frozen balls of ice containing fish elicited most of the changes in the lions' behaviour and could thus be said to be most effective than scents (musk cologne, peppermint, allspices and almond extract) and 2) Skibiel et al. [13] observed that the proportion of time spent pacing significantly decreased more during presentation of frozen fish (-26.58%) than during spices (-21.25%).

The welfare of felids in captivity is very difficult to achieve because the hunting -considered as one of the most important species-typical behaviour is not being reproduced totally and it provokes stereotyped behaviours and digestive problems. It will be important to know how the absence of this behaviour affect to their welfare and to consider what kind of species are less susceptible to maintain in captive conditions. It includes: 1) enclosure design (climatic conditions, size and furniture); 2) diet (type, presentation, frequency and seasonal variation); 3) social requirements (solitary, social, breeding programme and multispecies exhibit); 4) enrichment programmes (design, evaluation, type and efficacy); 5) training sessions with veterinary aims; 5) veterinary treatment (breeding control, congenital illness and vaccines); and 6) visitors' effect on welfare [34].

One of the most limitations of this study is the few studied enrichment sessions and the few published studies about enrichment response between the adults and the juveniles. Future studies should include microevaluation variables (the number of interaction/animal, the number of animals interacting with enrichment, the time spent interacting with enrichment, the enrichment item latency, and so on) in order to know more details about the efficacy of enrichment items and how each animal interact with them. This evaluation should be useful to increase the enrichment efficacy and as a consequence animal welfare.

Acknowledgements

This study could not have been carried out without the help and active participation of the team of keepers at Barcelona Zoo: Miquel Griñó, Óscar Quílez, Oriol Borrut, Ramón Cardona and Maribel Moragas. Finally, thanks to Carlota Curriu, Marc Escobar and Agnès Collia for their cooperation.

References

1. Mellen JD, MacPhee MS (2001) Philosophy of environmental enrichment: past, present and future. Zoo Biol 20: 211-226.
2. Hosey G, Melfi V, Pankhurst S (2013) Zoo animals: behaviour, management, and welfare. Oxford, England, UK.
3. Shepherdson DJ (2003) Environmental enrichment: past, present and future. Int Zoo Yb 38: 118-124.
4. Soriano AI, Vinyoles D, Maté C (2016) Long-term macroevaluation of environmental enrichment in three brown bears (Ursus arctos) at Barcelona Zoo. J Appl Anim Welf Sci 19:1-13.
5. McPhee MS (2002) Intact carcasses as enrichment for large felids: effects on on- and off-exhibit behaviors. Zoo Biol 21: 37-47.
6. Walters T (2003) Observations of the short-term behavioural response of a captive male tiger (Panthera tigris) to changes in feeding enrichment. Ratel 30: 29-47.
7. Ruskell AM, Meiers ST, Jenkins SE, Santymire RM (2015) Effect of bungee-carcass enrichment on behaviour and fecal glucocorticoid metabolites in two species of zoo-housed felids. Zoo Biol 34: 170-177.
8. Quirke T, O' Riordan RM (2012) Evaluation and interpretation of the effects of environmental enrichment utilizing varying degrees of sampling effort. Zoo Biol 32: 262-268.
9. Shepherdson DJ, Carlstead K, Mellen J, Seidensticker J (1993) The influence of food presentation on the behavior of small cats in confined environments. Zoo Biol 12: 203-216.
10. Charlton N (1998) The effects of an environmental enrichment device on the behaviour of captive jaguars. Ratel 25: 178-188.
11. Bashaw MJ, Bloomsmith MA, Marr MJ, Maple TL (2003) To hunt or not to hunt?: A feeding enrichment experiment with captive large felids. Zoo Biol 22: 189-198.
12. Bond JL, Lindburg DG (1990) Carcass feeding of captive cheetahs (Acinonyx jubatus): the effects of a naturalistic feeding program on oral health and psychological well-being. Appl Anim Behav Scie 26: 373-382.
13. Skibiel AM, Trevino HS, Naugher K (2007) Comparison of several types of enrichment in captive felids. Zoo Biol 26: 371-381.
14. Van Metter JE, Harriger MD, Bolen RH (2008) Environmental enrichment utilizing stimulus objects for African lions (Panthera leo leo) and Sumatran tigers (Panthera tigris sumatrae). Bios 79: 7-16.
15. Quirke T, O' Riordan RM (2011) The effect of a randomised enrichment treatment schedule on the behaviour of cheetahs (Acinonyx jubatus). Appl Anim Behav Sci 135: 103-109.
16. Markowitz H, Aday C, Gavazzi A (1995) Effectiveness of acoustic "prey": environmental enrichment for captive African leopard (Panthera pardus). Zoo Biol 14: 371-379.
17. Damasceno J, Genaro G, Quirke T, McCarthy S, McKeown S, et al. (2017) The effects of intrinsic enrichment on captive felids. Zoo Biol 36: 186-192.
18. Powell DM (1995) Preliminary evaluation of environmental enrichment techniques for African lions (Panthera leo). Anim Welf 4: 361-370.
19. Kendal RL, Coe RL, Laland KN (2005) Age differences in neophilia, exploration, and innovation in family groups of Callitrichid monkeys. Am J Primatol 66: 167-188.
20. Glickman SE, Sroges RW (1966) Curiosity in zoo animals. Behav 26: 151-188.
21. Jaman MF, Huffman MA (2011) Age class differences in the feeding behaviour of captive Japanese macaques (Macaca fuscataia) in the forested and nonvegetated enclosure groups. Zoo Biol 30: 260-274.
22. Eskelinen HC, Winship KA, Borger-Turner JL (2015) Sex, age, and individual differences in Bottlenose dolphins (Tursiops truncatus) in response to environmental enrichment. Anim Behav and Cogn 2: 241-253.
23. Altmann J (1974) Observational study of behavior: sampling methods. Behav 49: 227-267.
24. Haberman SJ (1978) Analysis of qualitative data 1. Academic Press, New York, USA.
25. Dickens M (1955) A statistical formula to quantify the "spread-of-participation" in group discussion. Speech Monographs 22: 28-31.
26. Soriano AI, Ensenyat C, Serrat S, Maté C (2006) Introducing a semi-naturalistic exhibit as structural enrichment for two brown bears (Ursus arctos). Does this ensure their captive well-being? J Appl Anim Behav Scie 9: 299-314.
27. Phillips C, Peck D (2007) The effects of personality of keepers and tigers (Panthera tigris tigris) on their behaviour in an interactive zoo exhibit. Appl Anim Behav Scie 106: 244-258.
28. Carlstead K (2009) A comparative approach to the study of keeper-animal relationships in the zoo. Zoo Biol 28: 589-608.
29. Martin P, Caro TM (1985) On the functions of play and its role in behavioural development. Adv Study Behav 15: 59-103.
30. Schaller GB (1972) The Serengeti lion: A study of predator-prey relations. The University of Chicago Press, Chicago, USA.
31. Mellen JD, Shepherdson DJ (1997) Environmental enrichment for felids: an integrated approach. Inter Zoo News 35: 191-197.
32. Law G, Macdonald A, Reid A (1997) Dispelling some common misconceptions about keeping of felids in captivity. Inter Zoo Yb 35: 197-207.
33. Margulis S, Hoyos C, Anderson M (2003) Effect of felid activity on zoo visitor interest. Zoo Biol 22: 587-599.

34. Irwin MD, Stoner JB, Cobaugh AM (2013) Zookeeping: An introduction to the science and technology. The University of Chicago Press, Chicago, USA.