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ARTICLE

# Effects of different environmental enrichment items on the behavior of the endangered Lear's Macaw (*Anodorhynchus leari*, Psittacidae) at Belo Horizonte Zoo, Brazil

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**ABSTRACT:** Environmental enrichment is a technique applied to enhance welfare of captive animals by introducing items that create a complex and stimulate enclosure. In poor environments, animals can exhibit abnormal and stereotypic behaviors due to boredom and stress. Animals behaving normally and with high levels of welfare are suitable and preferred to participate in conservation efforts such as reintroductions. The aim of this study was to evaluate the effects of environmental enrichment items on the behavior of the endangered Lear's Macaws held at the Belo Horizonte Zoo, Brazil. Ninety hours of behavioral data were collected, divided into three equal-length treatments: baseline, enrichment and post-enrichment. Data were collected using focal sampling with instantaneous recordings every minute. Environmental enrichment decreased the expression of abnormal behaviors and increased macaw activities. Thus, environmental enrichment proved to be effective in the maintenance of normal behaviors and should be continually used to increase the welfare of Lear's Macaws.

**KEY-WORDS:** abnormal behavior, bird, food enrichment, Psittaciformes, welfare.

## INTRODUCTION

Animal welfare can be defined as the maintenance of good physical and mental health of animals by attending their needs (Young 2003). Animal welfare can be compromised in captivity due mainly to stress caused by the limited space, high number of individuals at the same cage or loneliness, and lack of stimulation (Newberry 1993, Morgan & Tromborg 2007, Borges *et al*. 2011). In such situations, animals can exhibit abnormal and stereotypic behaviors (Mason & Rushen 2006, Mason 2010); the most common abnormal behaviors recorded for birds are feather plucking, pacing, self-mutilation, and bar or/and wall pecking (Engebretson 2006, Speer 2014).

Environmental enrichment is a technique created to increase the welfare of captive animals (Shepherdson *et al.* 1998). It consists in the introduction of items inside the enclosure that stimulate animals to behave normally (Young 2003). Enrichment items provide the opportunity to increase exploratory, consummatory, predatory and social behaviors, as well as to enhance motor skills, decreasing stress and the expression of abnormal behaviors, ameliorating animal welfare (Cubas *et al.* 2006). Thus, it is important to provide environmental enrichment for captive animals, as the reduction of stress levels is normally followed by an increase in reproduction success, which helps in species conservation efforts (Pizzutto *et al.* 2009).

Lear's Macaw (*Anodorhynchus leari*, Psittacidae) is an endangered Brazilian bird (MMA 2014, IUCN 2015), only occurring in Jeremoabo, Euclides da Cunha and Canudos municipalities, in Bahia state, northeastern Brazil (Lima *et al.* 2003). The main threats to the species are hunting, habitat destruction, and illegal trade (ICMBio 2012). According to the latest census of the species, only 1294 macaws were recorded in natural habitat in 2014 (CEMAVE, unpub. data). Due to its rarity, Brazilian zoos kept in their collections only 31 individuals of the Lear's Macaw in 2010, being three held at Belo Horizonte Zoo (BH Zoo), Minas Gerais state, southeastern Brazil (ICMBio 2012). Macaws are often considered as "hard-

fruit specialist" birds, including a number of hard-husked fruits (*e.g.* palms) in their diet, especially the Licuri Palm (*Syagrus coronata*, Arecaceae) (Brandt & Machado 1990, Sick 1997, Lima *et al*. 2014). Its specialized diet also contributes to its threat status, since Licuri Palm has been used in the commerce and subsistence of local people in Bahia (Crepaldi *et al.* 2004). To keep the welfare of captive individuals is important, among other reasons, because they can be reintroduced in the wild or being part in a captive reproduction management, since wild populations of *A. leari* shows low levels of genetic variation (Presti *et al.* 2011), thus, contributing effectively to the conservation and maintenance of wild populations.

Some studies have been conducted applying environmental enrichment to psittacines (Field & Thomas 2000, Evans 2001, Kim *et al*. 2009, Sgarbieiro 2009, Webb *et al*. 2010, Andrade & Azevedo 2011, van Zeeland *et al*. 2013), but none evaluated how environmental enrichment influences Lear's Macaw behaviors or any other *Anodorhynchus* species. In general, psittacines respond positively to enrichment, decreasing the expression of abnormal behaviors and increasing the expression of normal behaviors. Thus, the aim of this study was to evaluate how environmental enrichment items would influence the behavior of two captive individuals of Lear's Macaw. We expected that environmental enrichment decreases the exhibition of abnormal behaviors and elicits more activity and normal behaviors.

## METHODS

### Study place, animals and maintenance

The study was conducted in an off-exhibit area of Belo Horizonte Zoo (BH Zoo; 19°51'S; 44°01'W). One male and one female Lear's Macaws were studied. Male was arising from the Lymington Aviary, São Paulo, Brazil; female was arising from the Loro Parque, Spain. Both individuals arrived at BH Zoo in 2010 and were held together in a 64 $m^2$, 4 m tall enclosure. Birds were fed twice a day at 09:00 h and 14:00 h with a mixture of parrot ration and vegetables. Water was provided *ad libitum*.

### Experimental protocol

The study was divided into three treatments of 30 h each, totalizing 90 h of behavioral data: baseline, enrichment (when the enrichment items were available) and post-enrichment (birds with no enrichment, when conditions returned to those of the baseline) (Young 2003). Behavioral data were recorded during the three experimental treatments, using focal sampling method associated with instantaneous recording of behaviors every minute (Altmann 1974). Data were collected on Mondays and Wednesdays, from 07:00 h to 09:00 h, and this time was chosen because macaws showed to be most active during this period of day (based on 12 h of preliminary observations made on September 2013). Each treatment lasted 15 days and the study was run from October to December 2013.

An ethogram was developed based on 12 h of preliminary observations and on scientific literature (Uribe *et al.* 1982, Prestes 2000, Schneider *et al*. 2006) (Table 1). Feather plucking and pacing were considered abnormal behaviors because they were performed in a stereotypic way (repetitive performance with no apparent reason; Mason & Rushen 2006).

The environmental enrichment items used were: bamboo forest, coconuts, grape, pumpkins filled with hazelnuts, hazelnuts wrapped in banana tree leaves, corn on the cob, parrot sticks, and cardboard boxes filled with

**TABLE 1.** Ethogram for Lear's Macaws (*Anodorhynchus leari*) studied at the BH Zoo, Brazil.

| Acronym | Behavior | Description |
|---|---|---|
| FED | Feeding | Macaw eats the ration. |
| VOC | Vocalizing | Macaw vocalizes. |
| WB | Walking on bars | Macaw walks hanged on bars by its feet or beak. |
| IN | Inactive | Macaw is inactive or sleeping. |
| FLY | Flying | Macaw flies through the enclosure. |
| ALP | Allopreening | Macaw manipulates the feathers of the other individual with its beak. |
| PAC | Pacing – abnormal behavior | Macaw walks from one side to another, repetitively and with no apparent reason. |
| WAL | Walking | Macaw walks on the perch. |
| HAB | Hanging on bars | Macaw hangs on the ceiling bars of the enclosure. |
| RUB | Rubbing beak | Macaw rubs its beak against the perch. |
| PEB | Pecking bars | Macaw pecks the bars of the enclosure. |
| MRO | Manipulating rocks | Macaw manipulates with its beak rocks caught on the enclosure's floor. |
| FPL | Feather plucking – abnormal behavior | Macaw plucks its own feathers. |
| II | Interacting with items | Macaw beaks the environmental enrichment items. |
| OTH | Other behaviors | Drinking water, scratching, and bathing. |

grass and coconut. Only one item was offered to the bird each day; each item was offered twice, and they were never offered in consecutive days. Items were inserted in the enclosure five minutes before data collection, once a day, and remained inside the enclosure until afternoon, when they were removed.

### Statistical analysis

Data were tested for normality using the Anderson-Darling test. Since data did not meet the requirements for parametric statistics, nonparametric statistical tests were used throughout. Friedman's test was used for comparing if the behavior of the macaws differed between treatments and environmental enrichment items. Dunn's test was used for *post-hoc* analysis in both comparisons (Zar 1998). Wilcoxon's test was used for comparing if the behaviors of male and female macaws differed between each other. All tests were run using Minitab 15®.

## RESULTS

### Comparison of behaviors expressed by macaws during the three treatments

During the enrichment treatment, male expressed more the feeding behaviors, interacting with items, and walking on bars (Table 2). Behaviors like inactive, walking on bars, and hanging on bars decreased during the enrichment treatment (Table 2). The abnormal behavior pacing decreased during the enrichment treatment, remaining low even during the post-enrichment treatment; the abnormal behavior feather plucking also decreased during the enrichment treatment, but increase in the post-enrichment treatment (Table 2). Vocalizing was exhibited more frequently during the post-enrichment treatment (Table 2).

Female fed, vocalized, walked on bars and interacted more with items during the enrichment treatment (Table 3). Inactivity was less frequently recorded during the enrichment treatment (Table 3). All other behavioral expressions were not influenced by the enrichment items (Table 3).

### Comparison between the behavioral expression of male and female macaws during the enrichment treatment

Seven behaviors differed between male and female macaws during the enrichment treatment: feeding, vocalizing, inactive, flying, interacting with items, walking and hanging on bars (Figure 1). Inactivity, hanging on bars and vocalizing were more commonly exhibited by the female when compared to the male; the three other behaviors were more expressed by the male macaw (Figure 1).

**TABLE 2.** Mean ± standard error of the number of behavioral registers and Friedman's results for the male Lear's Macaw of BH Zoo, Brazil, during the three treatments of the study (baseline, enrichment and post-enrichment). FEE – feeding; VOC – vocalizing; WB – walking on bars; IN – inactive; FLY – flying; ALP – allopreening; PAC – pacing; WAL – walking; HAB – hanging on bars; RUB – rubbing beak; PEB – pecking bars; MRO – manipulating rocks; FPL – feather plucking; II – interacting with items; OTH – other behaviors. Same superscript letters indicate statistical differences between treatments according to the Dunn's *post-hoc* test.

| Behavior | Treatments | | | F | P |
|---|---|---|---|---|---|
| | Baseline | Enrichment | Post-enrichment | | |
| FEE | 19.06 ± 1.32 | 44.40 ± 4.26[a] | 13.80 ± 1.26[a] | 22.53 | <0.0001 |
| VOC | 25.73 ± 2.56 | 18.46 ± 3.40[a] | 31.00 ± 1.79[a] | 7.23 | 0.0269 |
| WB | 6.73 ± 1.00[a] | 1.60 ± 0.49[ab] | 8.26 ± 1.13[b] | 13.63 | 0.0011 |
| IN | 11.73 ± 2.50[ab] | 1.13 ± 0.53[a] | 2.80 ± 1.05[b] | 11.70 | 0.0029 |
| FLY | 2.26 ± 0.35 | 1.33 ± 0.46 | 0.93 ± 0.30 | 3.73 | 0.1546 |
| ALP | 2.13 ± 0.46 | 2.26 ± 0.76 | 2.20 ± 0.49 | 0.40 | 0.8187 |
| PAC | 1.66 ± 0.56[a] | 0.93 ± 0.38 | ----[a] | 6.53 | 0.0381 |
| WAL | 4.00 ± 0.74 | 4.00 ± 1.55 | 3.93 ± 0.93 | 1.90 | 0.3867 |
| HAB | 21.86 ± 1.24[a] | 15.40 ± 3.48[b] | 42.66 ± 2.59[ab] | 22.43 | <0.0001 |
| RUB | 1.06 ± 0.37 | 0.26 ± 0.15 | ---- | 4.13 | 0.1266 |
| PEB | 5.33 ± 1.24 | 1.60 ± 0.46 | 3.13 ± 0.72 | 3.33 | 0.1889 |
| MRO | 3.46 ± 0.88 | 0.86 ± 0.44 | 0.46 ± 0.25 | 5.70 | 0.0578 |
| FPL | 7.13 ± 1.72[a] | 0.53 ± 0.32[a] | 4.40 ± 1.11 | 8.40 | 0.0150 |
| II | 5.73 ± 1.73[a] | 25.80 ± 3.64[ab] | 3.20 ± 0.93[b] | 20.43 | <0.0001 |
| OTH | 2.06 ± 0.62 | 1.40 ± 0.58 | 3.20 ± 1.20 | 2.63 | 0.2680 |

**TABLE 3.** Mean ± standard error of the number of behavioral registers and Friedman's results for the female Lear's Macaw of BH Zoo, Brazil, during the three treatments of the study (baseline, enrichment and post-enrichment). FEE – feeding; VOC – vocalizing; WB – walking on bars; IN – inactive; FLY – flying; ALP – allopreening; PAC – pacing; WAL – walking; HAB – hanging on bars; RUB – rubbing beak; PEB – pecking bars; MRO – manipulating rocks; FPL – feather plucking; II – interacting with items; OTH – other behaviors). Same superscript letters indicate statistical differences between treatments according to the Dunn's *post-hoc* test.

| Behavior | Treament | | | F | P |
|---|---|---|---|---|---|
| | Baseline | Enrichment | Post-enrichment | | |
| FEE | 19.26 ± 1.20 | 30.00 ± 3.12[a] | 11.73 ± 1.10[a] | 16.90 | 0.0002 |
| VOC | 37.06 ± 3.33 | 32.13 ± 3.13[a] | 38.73 ± 2.05[a] | 9.30 | 0.0096 |
| WB | 6.33 ± 0.78[a] | 1.53 ± 0.37[a] | 3.20 ± 0.89 | 10.83 | 0.0044 |
| IN | 21.66 ± 4.52 | 6.20 ± 1.63[a] | 28.33 ± 2.85[a] | 16.23 | 0.0003 |
| FLY | 0.93 ± 0.26 | 0.26 ± 0.15 | 0.40 ± 0.21 | 2.53 | 0.2818 |
| ALP | 2.13 ± 0.46 | 2.26 ± 0.76 | 2.20 ± 0.49 | 0.40 | 0.8187 |
| PAC | 2.66 ± 1.29 | 0.53 ± 0.36 | 0.20 ± 0.20 | 3.03 | 0.2194 |
| WAL | 0.86 ± 0.41 | 1.46 ± 0.59 | 0.93 ± 0.30 | 0.13 | 0.9355 |
| HAB | 20.13 ± 2.40 | 26.86 ± 3.88 | 31.40 ± 2.32 | 5.20 | 0.0743 |
| RUB | 0.46 ± 0.32 | 0.53 ± 0.29 | ---- | 0.70 | 0.7047 |
| PEB | 3.46 ± 1.12 | 2.20 ± 0.69 | 1.80 ± 0.51 | 2.63 | 0.2680 |
| MRO | 1.33 ± 0.60 | 1.66 ± 0.59 | 0.66 ± 0.41 | 1.63 | 0.4419 |
| FPL | ---- | ---- | ---- | 0.00 | 1.0000 |
| II | 2.26 ± 0.93[a] | 13.53 ± 2.93[ab] | 0.26 ± 0.26[b] | 14.23 | 0.0008 |
| OTH | 1.40 ± 0.41 | 0.80 ± 0.41 | 0.13 ± 0.13 | 4.43 | 0.1090 |

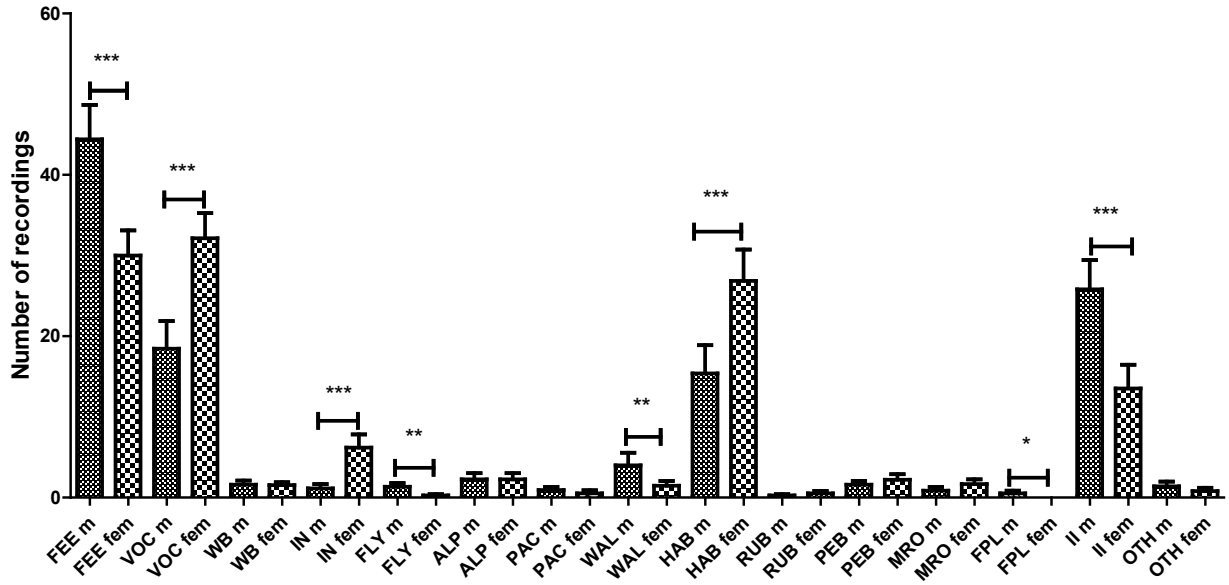


**FIGURE 1.** Comparison between the behaviors expressed by the male (m) and female (fem) Lear's Macaws of BH Zoo, Brazil, during the environmental enrichment treatment. Wilcoxon results: * P < 0.05; ** P < 0.01; *** P < 0.001. FEE – feeding; VOC – vocalizing; WB – walking on bars; IN – inactive; FLY – flying; ALP – allopreening; PAC – pacing; WAL – walking; HAB – hanging on bars; RUB – rubbing beak; PEB – pecking bars; MRO – manipulating rocks; FPL – feather plucking; II – interacting with items; OTH – other behaviors.

### Comparison between the behavioral expressions of macaws in relation to the different environmental enrichment items

All behaviors expressed by the male were exhibited equally with all enrichment items. Female became more inactive when using the corn on the cob item, and expressed more frequently the behavior manipulating rocks when grapes were offered as enrichment (Figure 2). All other behaviors were expressed in the same amount by the female macaw, independent on the environmental enrichment item offered.

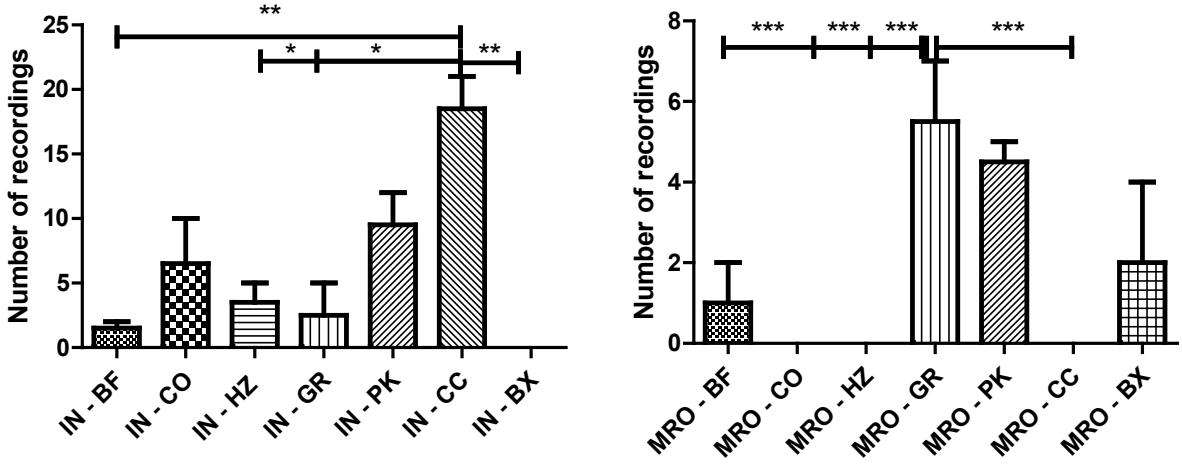


**FIGURE 2.** Comparison between the behaviors expressed by female Lear's Macaw of BH Zoo, Brazil, during the offering of the environmental enrichment items. Friedman results: * P < 0.05; ** P < 0.01; *** P < 0.001. IN – inactive; MRO – manipulating rocks; BF – bamboo forest; CO – coconut; HZ – hazelnuts wrapped in banana tree leaves; GR – grape; PK – pumpkins filled with hazelnuts; CC – corn on the cob; BX – cardboard boxes filled with grass and coconut.

## DISCUSSION

Environmental enrichment proved to be positive for the male Lear's Macaw since its abnormal behaviors (pacing and feather plucking) decreased and its activity increased with its use. For the female Lear's Macaw, although the expression of the abnormal behavior pacing presented a slightly decrease during the enrichment treatment, this difference was not significantly, showing that the environmental enrichment items were not sufficient to modify this behavior.

The use of environmental enrichment for parrots is now common and results are in general positive, with birds increasing their activity and diminishing the exhibition of abnormal behaviors (Coulton *et al*. 1997, Meehan *et al*. 2004, Lumeij & Hommers 2008, Andrade & Azevedo 2011). Foraging increased significantly for both Lear's Macaws studied: despite the availability of their regular diet, macaws forage more upon the enrichment items, providing more evidence for contrafreeloading in psittacines, as observed by Coulton *et al*. (1997), Inglis *et al*. (1997) and Lumeij & Hommers (2008). The increase in activity levels could be related to the increase in food ingestion due to the food enrichments; more food ingested means more energy available for activities (Crocker *et al.* 2002). Decrease in inactivity has been related to the increase of welfare of birds (Azevedo & Faggioli 2001, Meehan 2002, Sgarbieiro 2009).

The abnormal behavior feather plucking is indicative of stress (Borges *et al.* 2011). Environmental enrichment decreased significantly this behavior for male Lear's Macaw (female did not express this behavior), reinforcing how important is to promote stimuli-rich captive environments for birds. Lumeij & Hommers (2008) showed that feather plucking was inversely related to foraging in African Gray Parrots (*Psittacus erithacus*). When food enrichment was offered to Grey Parrots, feather plucking almost disappeared. In nature, parrots forage for more than 6 h per day (Snyder *et al*. 1987), but in captivity this behavior can last less than 20 minutes, allowing parrots to spend more time exhibiting other behaviors, such as feather plucking, especially in cages without proper stimuli. The reduction of feather plucking by male Lear's Macaw indicated that his welfare increased.

Pacing, another abnormal behavior indicative of stress, decreased both for male and female Lear's Macaws, but not significantly during the enrichment treatment. The same result was found by Andrade & Azevedo (2011) when studying Turquoise-fronted Parrot (*Amazona aestiva*). This reduction may indicate that although items stimulated the expression of more normal behaviors, they were not capable to extinguish the expression of pacing, and new items should be tested.

The exhibition of walking on bars decreased during the enrichment treatment, what was also observed by Andrade & Azevedo (2011), and this result was related to the increase of interaction with items. Macaws walked to the enrichment items and spent long periods interacting with them.

Both macaws exhibited the behavior manipulating rocks. Meehan *et al*. (2004) stated that when psittacines live on non-enriched cages, they tend to chew bars, perches or rocks to wear their beaks. This activity occupy the time of birds, diminishing tediousness (Meehan *et al*. 2004). However, when expressed for long periods of time, this behavior can be considered abnormal. Assis (2013) observed that Cockatiel (*Nymphicus hollandicus*) living in enriched cages chew less than Cockatiels living in non-enriched cages. In the present study, male Lear's Macaw showed a significant decrease of the expression of the manipulating rock behavior, but the female showed no difference between treatments. We hypothesized that

or the enrichment items used were not sufficient to wear the beak of the female, or this behavior was exhibited in an abnormal way (quantitatively abnormal). Behavioral budget and veterinary evaluations on the beak growth and size could be conducted to test these hypotheses. More abrasive environmental enrichment items could also be provided to help birds in beak wearing.

None enrichment items used in this study elicited different behaviors exhibited by male Lear's Macaw, but corn on the cob stimulated the female become more inactive than other items, and grape stimulated more manipulating rock than other items. Grape was one of the softest enrichment items used and the lack of abrasive characteristics may stimulated rock use. Corn on the cob was almost ignored by the female, which may be responsible for the increase in inactivity when this item was offered.

In conclusion, both food and physical enrichment influenced the behaviors expressed by Lear's Macaws, most positively, increasing macaw activity and decreasing the amount of abnormal behaviors expressed by the male. Male and female, however, differed in their responses to the enrichment items, thus, the results should be taken carefully. Additional items should be experimented and evaluated, aiming the extinction of abnormal behaviors for birds, but a routine of environmental enrichment, with items that elicits different birds senses and skills, should be implemented.

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