



Nocturnal birds of prey in captivity: a study in the owl *Strix virgata* (Strigidae)

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ABSTRACT

Objective. To observe the behavior, hormonal patterns, and welfare in captive mottled owl *Strix virgata* (Strigidae). **Materials and methods.** The study was conducted at environmental management units (UMA) in Xalapa, Mexico, on six owls: two females in one enclosure, one male and one female in another, all without public exhibition and with environmental enrichment, and two isolated owls, kept caged or perched, with daytime public exhibition. Behaviors were monitored in each pair or individual during 120 hours of filming (60 h during the day and 60 h at night). Concentrations of fecal metabolites of corticosterone, estradiol, and progesterone were measured, and welfare was assessed with observational indicators and surveys. **Results.** The paired owls showed normal behaviors and excellent welfare (95.5%), while the isolated individuals showed undesirable behaviors and regular welfare (51.4%). Of 24 behaviors considered in an ethogram, 11 were observed repeatedly in all specimens. The isolated birds had higher agonistic, feeding, and individual activity ($p < 0.001$) than the paired birds, although it did not result in lower levels of corticosterone ($p = 0.09$) nor estrogens ($p = 0.29$) in females, only in progesterone ($p = 0.001$). **Conclusions.** In captive mottled owls, daytime exhibition and inadequate facilities promote the presence of undesirable behaviors that can affect their welfare. Therefore, the use of enrichment measures, such as larger enclosures, feeding at night, and pair housing (female and male, or two females) should be considered to reduce the negative effects of captivity and increase their welfare.

Keywords: Animal behavior; animal reproduction; pathophysiological effects; strigiformes (*Source: ICYT Tesseract of Animal Biology*).

RESUMEN

Objetivo. Observar el comportamiento, patrones hormonales y bienestar del búho café *Strix virgata* (Strigidae) en cautiverio. **Materiales y métodos.** El estudio se realizó en unidades de manejo ambiental (UMA) en Xalapa, México, con seis búhos: dos hembras en un encierro, un macho y una hembra en otro, todos sin exhibición al público y con enriquecimiento ambiental, y dos

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individuos aislados, en jaula y percha, con exhibición diurna al público. Se observaron las conductas de cada par o individuo durante 120 h de filmación (60 h diurnas y 60 h nocturnas). Se midieron concentraciones de metabolitos fecales de corticosterona, estradiol y progesterona y se evaluó el bienestar con indicadores por observación y encuestas. **Resultados.** Los búhos en par presentaron comportamientos normales y bienestar excelente (95.5%), mientras que los individuos aislados mostraron conductas indeseables y bienestar regular (51.4%). De 24 conductas consideradas en un etograma, se observaron 11 de forma repetida en todos los animales. Las aves aisladas tuvieron mayor actividad agonista, alimentaria e individual ($p < 0.001$) que las aves en pares, aunque esto no se reflejó en menores niveles de corticosterona ($p = 0.09$) ni estrógenos ($p = 0.29$) en hembras, sólo en progesterona ($p = 0.001$). **Conclusiones.** En búhos café en cautiverio, la exhibición diurna y las instalaciones inadecuadas promueven la presencia de comportamientos indeseables que pueden afectar su bienestar. Por tanto, se debe considerar la utilización de enriquecimiento como la ampliación de encierros, alimentación nocturna y alojamiento en pares (hembra y macho, o dos hembras), para disminuir los efectos negativos del cautiverio e incrementar su bienestar.

Palabras clave: Comportamiento animal; efectos fisiopatológicos; reproducción animal; strigiformes (Fuente: Tessauro ICYT de Biología Animal).

INTRODUCTION

The mottled owl *Strix virgata* (Strigidae), which lives in American tropical and subtropical ecosystems, has increased its contact with humans because as happens with other raptors, the fragmentation of its habitat has led to greater exposure to anthropogenic stressors (1,2).

In captivity, the life conditions for these birds elapse in reduced spaces and without enclosures, which leads to problems due to chronic stress and undesirable behaviors in response to harmful stimuli (3).

This can inhibit reproduction due to the release of glucocorticoids (4), besides promoting the presence of negative responses such as fear, aggression, or stereotypies, in repeated actions with no obvious function (5).

These birds can even perform some behaviors that can end in self-mutilation. Because of this, it is recommended to implement environmental enrichment measures at zoos and breeding centers, to decrease the negative effects of captivity and promote animal welfare (5).

Such welfare can be evaluated by measuring its presence or absence through corticosteroids concentrations, since they vary in response to the environmental stimuli by increasing the pituitary-adrenal activity. To this respect, in lab animals it has been established the relationship between corticosteroid levels and the intensity and way the behavioral responses are presented (5,6).

In this context, the objective of the present study was to observe the behavior, hormone patterns, and welfare indicators in mottled owls *Strix virgata* (Strigidae) under different captivity conditions.

MATERIALS AND METHOD

Study area. The study was conducted during one year, in different stages, at three environmental management units (UMA) located in the city of Xalapa, in Veracruz, Mexico (Lat. 19°14'N and Long. 98°01'W) at 1580 masl. The climate in the area is warm sub-humid with mean annual temperature of 21°C, annual rainfall of 1100 to 1600 mm, with predominant vegetable stratum corresponding to mountain mesophilic forest (7).

Study animals. Six adult mottled owls (five females and one male), in which the sex was determined through blood samples (Laboratorio de Biotecnología ID GEN®, Patzcuaro, Michoacan, Mexico) (Table 1) were included in the study. Owls 1 and 2 belonged to one UMA each, and were individually housed and with public exhibition 8 hours daily (10:00 to 18:00 h). Owl 1 was in a wire cage (51 cm height x 35 cm length x 27 cm width) with three wooden perches and visual contact with other raptors. During the daytime, the cage was placed in different places at the UMA, and was kept inside a building during rainy time. The owl left the cage only to be photographed with the people visiting the UMA, and the diet, which was offered from 12:00 to 15:00 h, consisted of 20-35 g of crushed chicken heads (fresh or frozen) and eventually rodents

(*Mus musculus* and *Rattus norvegicus*) raised in their own vivariums. There was no water source, so the bird was hydrated exclusively from the food. Owl 2 was in an open area, standing on a fixed metal perch covered with synthetic grass, and with jesses, which allowed the bird's movement. In the rainy season the owl was kept inside a roofed room. Its diet was similar to that offered to Owl 1 and had daily access to water.

Owls 3, 4, 5, and 6 belonged to one UMA, were housed in pairs and were not exhibited to the public. They had visual contact with humans only during feeding, cleaning or handling. Females 3 and 4 shared one enclosure, and female 5 together with male 6 shared another enclosure. These enclosures were built with concrete and had wire all around, with approximate dimensions of 5 m length x 3 m width x 2 m height, painted in green and having shade fabric for temperature and humidity regulation. These enclosures had double security doors, thermometer and hygrometer (Elitech RC-51H). Drinking water was offered *ad libitum* in mobile recipients and in fixed tanks for bathing. The daily food ration per owl was 60-100 g of mouse (*Mus musculus*), rat (*Rattus norvegicus*) or lesser jerboa (*Jaculus jaculus*) raised in the own vivarium, or with offspring of chicken (*Gallus gallus domesticus*), quail (*Coturnix coturnix*) or rabbit (*Oryctolagus cuniculus*) that were purchased. Enrichment activities were conducted daily and were the usual at the UMA in the enclosures of the four owls, and were based on the exchanging of several objects such as pieces of wood, plants, perches, or nests.

Table 1. Characteristics of the mottled owls *Strix virgata* (Strigidae) kept under captivity at environmental management units in Xalapa, Veracruz, Mexico.

Owl	Sex	Age (years)	Weight (g)
1	female	1	283
2	female	7	371
3	female	8	329
4	female	5	337
5	female	2	330
6	male	4	298

Behavior. The activity patterns were established based on focal observations and samplings with camera traps (Cudde Back® Black, Green

Bay, US) during 120 hours straight, 60 h in the daytime (06:00-19:59 h) and 60 h during the night (20:00-05:59 h). The recordings were simultaneous for all the individuals, every 10 seconds, and during 24 hours.

From a methodology with ethograms, which was adapted for this study based on the literature and in previous observations, 24 behaviors within 4 categories were established: 1. affiliative (pair grooming, pair perching); 2. agonist (fleeing, displacement); 3. feeding (stalking, tearing apart, ingesting, beak cleaning, movement with prey, gripping prey, flying with prey); 4. individual (fallen wings, grooming, wing flapping, resting, bathing, lying down, feather bristling, stretching, locomotion, watching the surroundings, staying sheltered, sleeping, flying).

Fecal hormone metabolites. During one year, in non-continuous periods, fecal samples were collected in glass flasks at maximum 30 min after being excreted. Once or twice a month (January, February, March-April, May-June, July-August, September, October, November-December) and during the morning hours (08:00-12:00 h), the same person collected the feces, after observing its excretion through direct observation of the owls.

From the excreta, the urates and fecal matter were separated using a steel spatula, and each fecal sample was transferred into a 2 ml microtube, which was marked for identification and transported in ice to the Wildlife Laboratory of the School of Veterinary Medicine at the Universidad Veracruzana to be stored at -20 °C.

In the lab, the samples were thawed and homogenized, and 5 mg from each sample were taken and added with 5 ml 60% methanol. After that, the samples were put in a vortex mixer for 15 min, and then they were centrifuged for 10 min at 727 G to recover the supernatant, which was stored in 2 ml cryotubes at -20 °C (8). The concentrations of fecal metabolites of corticosterone, progesterone, and estradiol were determined in the females, and corticosterone in the male, in all cases through enzyme-linked immunoassay (ELISA) using commercial kits (DRG Diagnostics® Marburg, DEU), following the instructions of the maker.

To determine the concentrations of the fecal hormone metabolites two dilutions were used, one control group and one standard at 15 nmol/L.

The range of the assay was 1-240 nmol/L, the sensitivity was <2 nmol/L, and the intra-assay coefficient of variation was 3%. The metabolite concentrations were read using a microplate reader (Epoch BioTek®, US) and were calculated using a dose-response curve, according to the absorbances obtained for each sample (Synergy Gen5, BioTek®, US). For data presentation, the metabolite concentrations obtained in nmol/L were transformed into ng/g of feces.

Animal welfare. The welfare indicators were evaluated by six specialists in wildlife handling, through an interview to the UMAs' workers. The interviewers used a guide of observation and a questionnaire modified from the Welfare Quality® assessment protocol for poultry (www.welfarequalitynetwork.net/media/1019/poultry_protocol.pdf). The criteria and schedule for interviews were validated by homologation by all the interviewing specialists. The level of welfare was considered from the total average with the percentages obtained with the guide of observation and the interview: 99-80% excellent, 79-60% satisfactory, 59-30% regular, and 29-0% deficient.

The fulfillment or the absence of the indicators of animal welfare considered in the guide was observed in the enclosures and in the animals longitudinally and focally. The total of items or questions was 47, divided into three categories: 1. The facilities and the management at the UMA, with 21 items, which evaluated the characteristics of the enclosures and the records kept (Table 2); 2. The behavior of the owls, with 14 items, which evaluated the effect of the surroundings and the contact with other birds and humans (Table 3); 3. The health status of the owls, with 12 items, which evaluated the signs of disease or lesions, and the condition of the plumage, the excreta, the beak, and the claws (Table 4). A maximum value of 33.3% was considered for each category, for a total sum of 99.9%.

The questionnaire for the interview to the UMA's workers was made of 21 questions on the practices, positive or negative, that

were conducted at the facilities, and on the management of the animals (Table 5). The interpretation of the results was made based on the relationship of the number of positive answers for animal welfare over the total number of questions: 21-17 positive answers was considered as excellent, 16-12 satisfactory, 11-6 regular, and 5-0 deficient.

Table 2. Indicators of animal welfare (facilities and management) in the guide of evaluation for mottled owls *Strix virgata* (Strigidae) kept under captivity at environmental management units in Xalapa, Veracruz, Mexico.

Facilities and management
1. The enclosures are safe for the handlers and the animals.
2. The owls are safe inside the enclosure.
3. The enclosures comply with the standards for the species that are handled (9).
4. The enclosures are built with materials that can be cleaned and disinfected.
5. There are isolation facilities available.
6. The enclosures have natural environmental characteristics or are enriched.
7. There are enough perches.
8. The area is ventilated.
9. The area has adequate lighting with some darkened spots.
10. The birds can avoid visual contact with people.
11. The enclosure is at least 2 meters away from people.
12. The pets cannot access the area.
13. The facilities are organized and built to minimize the stress in the birds.
14. Each cage or enclosure has water supply.
15. The bird has shelter inside the cage or enclosure.
16. The records of each bird are kept.
17. The records are legible.
18. The records are correctly filled (the progress of each animal can be followed).
19. There is a system to identify each bird.
20. There is a medical record for each bird which is sick or undergoing treatment.
21. All the birds have a medical record.

Table 3. Indicators of animal welfare (behavior) in the guide of evaluation for mottled owls *Strix virgata* (Strigidae) kept under captivity at environmental management units in Xalapa, Veracruz, Mexico.

Behavior
1. The owl's circadian cycle is inverted.
2. The owl has contact with conspecific individuals.
3. The owl has contact with animals of a different species (possible predators).
4. The owl vocalizes, clicks the beak, or hisses when in close proximity to humans.
5. The owl displays abnormal behaviors.
6. The owl has motivating surroundings to display its normal behavior.
7. The owl can freely fly from one perch to another.
8. When directly interacting with humans, the owl defecates in response to preparation to flight.
9. When directly interacting with humans, the owl makes subtle changes in its posture.
10. When directly interacting with humans, the owl makes quick head movements looking for a route of escape.
11. When directly interacting with humans, the owl attempts fighting.
12. When directly interacting with humans, the owl has dilated pupils.
13. When directly interacting with humans, the owl pants or drools in response to handling.
14. When directly interacting with humans, the owl flees, crashing directly against walls, perches, and people.

Table 4. Indicators of animal welfare (health status) in the guide of evaluation for mottled owls *Strix virgata* (Strigidae) kept under captivity at environmental management units in Xalapa, Veracruz, Mexico.

Health status
1. The owl shows signs of disease.
2. The owl shows signs of lesion.
3. The owl shows some stereotypy.
4. The owl looks uncomfortable under captivity.
5. The condition of the perches or the enclosure damages the owl's plumage.
6. The condition of the perches damages the owl's feet or claws.
7. The restraining or holding equipment damages the owl's plumage.
8. The owl's weight is not adequate (adults: 320-340 g males and 340-380 g females).
9. The owl's plumage is damaged (indicate the region in the sketch).
10. The consistency, shape, and color of the excreta are not normal.
11. The beak has abnormal growth or shape.
12. The claws have abnormal growth.

Table 5. Interview for evaluation of animal welfare applied to workers at the environmental management units that house mottled owl *Strix virgata* (Strigidae) in Xalapa, Veracruz, Mexico.

Interview for evaluation
General information <ol style="list-style-type: none"> 1. What is the number of living wild animals housed, and the number or other wild species, kept at the UMA? 2. What is the approximate area available for the keeping of these species? 3. How many people work full-time and part-time at the UMA? What is the age and sex of the workers? Feeding management <ol style="list-style-type: none"> 4. What type of food do the owls receive? Chicken, rat, mouse, invertebrates (specify), other (specify). Reproductive management <ol style="list-style-type: none"> 5. What methods do you use for the owls' reproduction and how many laying of eggs do you have each year? Do you hire extra workers with technical background for the breeding season? General management of the owls <ol style="list-style-type: none"> 6. How many hours a day, a month, or a year do the owls fly? 7. Do the owls have access to shelter or shade? 8. Do the owls have continuous access to sources of water? 9. What is the purpose of the owls at the UMA? 10. When the owl is at the UMA for rehabilitation, is the process based in a validated program? When the purpose of the owl is exhibition or environmental education, does the keeping of the owl consider a continuous program of environmental enrichment? When the owl is at the UMA for reintroduction, has the owl been quarantined and received follow-up during its rehabilitation? 11. Have you ever performed preventive medical check-ups to the owls? Do you keep individual medical records? 12. How often do you clean the substrate of the enclosures? Management of mutilations in the owls <ol style="list-style-type: none"> 13. Do you perform trimming of the beak and claws?

Animal welfare of the owls

14. Have you received training on animal welfare in the last 12 months?
15. Have you received training on the management of raptors in the last 12 months?
16. Do you think that the raptors are capable of having emotions and feeling pain?
17. Do you think that the raptors are conscious of what they do or that they just respond mechanically to the stimuli?
18. Can you tell when an owl is suffering?
19. Do you think that the absence of welfare has negative consequences on the owl's health?
20. Do you think that sedentariness in owls is an animal welfare related problem?

Sanitary management at the UMA

21. In the last 12 months, how many wild animals have died at the UMA: due to advanced age, deficient nutrition, disease, accident? Or negligence?

Ethical aspects. The owls were not handled during this study. The behavioral variables were evaluated remotely and the fecal samples were obtained without disturbing the birds. The animal welfare indicators were obtained by specialists.

Statistical analysis. The frequency of the observed and expected behaviors among the owls was analyzed using the goodness-of-fit test (Chi-square), comparing the diurnal and nocturnal behaviors in three groups: females 1 and 2, females 3 and 4, and female 5 with male 6. The levels of fecal hormone metabolites were compared using an analysis of variance, (ANOVA) with an expected value of $p < 0.05$. The animal welfare indicators for Owls 1, 2, 3, 4, 5, and 6 were compared with their respective percentages obtained, according to the categories previously mentioned in the guide of observation and in the interviews.

RESULTS

Behavior. Owls 3, 4, 5, and 6 showed the 24 behaviors from the ethogram, whereas Owl 1 only showed 12 behaviors and Owl 2 14 behaviors. These two owls did not show affiliative, grooming, and perching in pair behaviors because they were isolated, nor locomotion, gripping or flying with

prey, bathing, staying in the shelter, or flying, because of the characteristics of their enclosure or housing.

Repeatedly, 11 behaviors were observed in all the owls. In the agonistic category, fleeing; in the feeding category, stalking and beak cleaning; in the individual category, grooming, wing flapping, resting, feather bristling, stretching, locomotion, watching the surroundings, and sleeping (Table 6).

Table 6. Frequency of behaviors observed in 120 hours in six mottled owls *Strix virgata* (Strigidae) kept in captivity.

Behavior	Owls	Day	Night
Agonistic			
Fleeing	1, 2	38	187
	3, 4, 5, 6	0	3
		$\chi^2=76.77^*$	$\chi^2=354.4^*$
Feeding			
Stalking	1, 2	120	0
	3, 4	3	123
	5, 6	7	120
		$\chi^2=205.72^*$	$\chi^2=122.81^*$
Beak cleaning	1, 2	6	0
	3, 4	13	67
	5, 6	5	74
		$\chi^2=4.8^{ns}$	$\chi^2=71.75^*$
Individual			
Grooming	1, 2	480	1194
	3, 4	303	697
	5, 6	374	962
		$\chi^2=41.68^*$	$\chi^2=131.66^*$
Wing flapping	1, 2	28	71
	3, 4	1	8
	5, 6	5	55
		$\chi^2=37.85^*$	$\chi^2=48.51^*$
Resting	1, 2	36368	41659
	3, 4	14261	17799
	5, 6	19685	16202
		$\chi^2=11448.73^*$	$\chi^2=16294.07^*$
Sleeping	1, 2	4539	8587
	3, 4	5850	739
	5, 6	776	4552
		$\chi^2=3766.9^*$	$\chi^2=6727.5^*$
Feather bristling	1, 2	19417	17676
	3, 4	1014	7399
	5, 6	2468	9535
		$\chi^2=27706.45^*$	$\chi^2=5339.91^*$
Stretching	1, 2	47	105
	3, 4	3	42
	5, 6	3	30
		$\chi^2=73.8^*$	$\chi^2=55.59^*$
Locomotion	1, 2	561	1051
	3, 4	83	335
	5, 6	105	278
		$\chi^2=589.28^*$	$\chi^2=676.06^*$
Watching the surroundings	1, 2	34831	27614
	3, 4	8893	16253
	5, 6	776	4552
		$\chi^2=43096.28^*$	$\chi^2=16649.2^*$

* $p < 0.001$ with 2 degrees of freedom; $^{ns} = p > 0.05$ with 2 degrees of freedom.

The behaviors during the day and night were different in Owls 1 and 2 in comparison with Owls 3 and 4, and 5 and 6 (Table 7). Within the agonistic behavior, the fleeing behavior had the highest frequency during the day and night.

Table 7. Difference in percentage of the frequency of behaviors shown by six captive individuals of mottled owl *Strix virgata* (Strigidae) during 120 hours of observations.

Behavior	Owls	Day	Night
Agonistic		%	%
Fleeing	1, 2	+203.00*	+193.61*
	3, 4	-100.00	-95.29
	5, 6	-100.00	-95.29
Feeding			
Stalking	1, 2	+179.72*	-100.00*
	3, 4	-93.01	-53.39
	5, 6	-83.68	-49.64*
Beak cleaning	1, 2	-24.24 ^{ns}	-100.00*
	3, 4	+64.14	+43.99
	5, 6	-36.78	+59.04
Individual			
Grooming	1, 2	+25.72*	+26.82*
	3, 4	-20.64	-25.97
	5, 6	-2.05	+2.18
Wing flapping	1, 2	+149.55*	+60.56*
	3, 4	-91.09	-81.91
	5, 6	-55.44	-24.38
Resting	1, 2	+56.73*	+66.85*
	3, 4	-38.54	-28.71
	5, 6	-15.16	-35.11
Sleeping	1, 2	+23.19*	+87.50*
	3, 4	+58.78	-83.86
	5, 6	-78.94	-0.61
Feather bristling	1, 2	+156.95*	+55.62*
	3, 4	-86.58	-35.59
	5, 6	-67.34	-17.00
Stretching	1, 2	+168.72*	+79.76*
	3, 4	-82.85	-28.09
	5, 6	-82.85	-48.64
Locomotion	1, 2	+126.97*	+549.12*
	3, 4	-66.42	-38.99
	5, 6	-57.52	-49.37
Watching the surroundings	1, 2	+166.25*	+72.82*
	3, 4	-47.80	+1.72
	5, 6	-114.78	-71.51

* $p < 0.001$ with 2 degrees of freedom; ^{ns} $p > 0.05$ with 2 degrees of freedom.

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In the feeding behavior, Owls 1 and 2 displayed more stalking behavior during the day, as they only received food during the day hours and, therefore, this behavior was absent during the night. The same case was for the beak cleaning. However, during the day, this last behavior was similar in all the owls.

Within the individual behavior, Owls 1 and 2 had more diurnal activity and nocturnal inactivity. The frequency of the diurnal behaviors with activity was higher for grooming, wing flapping, stretching and locomotion. Similarly, the nocturnal frequency was higher for the behaviors with inactivity, such as resting, feather bristling, sleeping and watching the surroundings.

Fecal hormone metabolites. In 267 fecal samples collected from the females, the average values of Owls 1 and 2 in comparison with those of Owls 3, 4, and 5 showed no differences in the concentrations of fecal metabolites of corticosterone ($F=2.14$, d.f.=4, $p=0.09$) or estradiol ($F=1.25$, d.f.=4, $p=0.29$). On the contrary, the concentrations of fecal progesterone metabolites ($F=6.57$, d.f.=4, $p=0.001$) were lower in Owls 1 and 2 (Table 8).

Table 8. Concentrations of fecal progesterone, estradiol, and corticosterone metabolites in mottled owl *Strix virgata* (Strigidae) females kept under captivity at environmental management units in Xalapa, Veracruz, Mexico.

	Progesterone ng/ml	Estradiol ng/ml	Corticosterone ng/ml
Owls 1, 2	0.36	0.10	4.38
Owls 3,4,5	0.61	0.11	5.38

Animal welfare. In the analysis of the welfare indicators, in both the guide of observation and the interviews with the UMAs' workers, Owls 1 and 2 had an average evaluation of 51.4%, which corresponds to a regular level of welfare. On the contrary, Owls 3, 4, 5, and 6 had an average evaluation of 95.5%, which corresponds to an excellent level of welfare (Table 9).

Table 9. Evaluation of animal welfare in mottled owl *Strix virgata* (Strigidae) according to the guide of observation and interview with the workers at the environmental management unit.

Guide of observation					Interviews: answers related to animal welfare		
Owls	FM*	B*	H*	Total	Positive answers	Total	Guide and interview
1	20.0	20.0	21.1	61.1	9/21	41.2	51.1%
2	14.0	13.3	17.4	44.8	12/21	58.8	51.8%
3	32.7	32.6	32.1	97.4	20/21	95.3	96.3%
4	32.7	32.6	32.1	97.4	20/21	95.3	96.3%
5	32.5	32.2	30.2	95.5	20/21	95.3	95.4%
6	32.5	30.9	29.3	92.7	20/21	95.3	94.0%

*Categories in percentage in the guide of observation by sections: FM=facilities-management, B=behavior, H=health.

DISCUSSION

In this study it could be observed that the changes in the behavior of the owls were due mainly to the characteristics of their enclosures or housings. To this respect, Hoehfurtner et al (11) found a direct relationship between the dimensions of the enclosure and the activity level of the individuals.

On the other hand, Liu et al (12) indicate that factors such as the complexity of the enclosure, the intensity of the light and sounds, and the presence of human visitors, enhance the manifestation of stereotypies.

This could be the case for the caged and perched owls, because if the minimal recommendations for captivity were not met, their behaviors of fleeing, stalking, grooming, wing flapping, stretching, and locomotion were increased.

Contreras et al (3) reported that in raptors the reactions of aggressiveness and fleeing can be indicators of good physical and psychological state. But when there are repeated attempts to do these behaviors, these actions usually indicate a stressful situation.

Regarding the diurnal and nocturnal behavior, de Busserolles et al (13) commented that, in nocturnal species, the density of the photoreceptors of the eye increased depending on their period of activity. To this respect, Rincón et al (14) reported that in owls their activities were more frequent between 19:00 and 22:00 h, which coincided with the observations in the owls *S. virgata* that were not exhibited to the public, but not in the owls that were exhibited to the public during the day hours.

Russart and Nelson (15) pointed out that the animals with nocturnal habits prefer a low level of lighting to sleep, which in this study was not the case for the owls that were exhibited to the public. This situation kept the owls from sleeping during the day hours, which is the time when the owls normally sleep, having this way their normal activity cycle inverted.

Another important factor was the exhibition to the public, since as noted by Sneddon (16), proximity with humans can modify the behavior of captive animals, inhibiting the display of some behaviors and increasing the display of others. In this context, De La Ossa (17) mentioned that the flight zone depends on the personality of the animal, which will mark differences among individuals.

Tame individuals may allow people to touch them, but those that keep their wild instinct tend to move away from people, as the limits of their flight zone are reached. In Owls 1 and 2, which were exhibited to the public, the option of having a flight zone was inhibited during the day hours as they were not able to move away or flee from people.

In these Owls 1 and 2, also the behaviors with inactivity such as resting, feather bristling, sleeping, and watching the surroundings were increased, both during the day and night. This behavior was similar to the one mentioned by Yon et al (18), who state that there is an increase in the resting hours in captive animals as a response to the stress caused by lack of activity or by excessive diurnal activity.

Raap et al (19) indicate that, in wild birds the regular cycles of light and darkness promote activity for the day and night hours. Therefore, when the frequency of these rhythms change, due to artificial environments and the absence of lighting variation, the behavior of the activity and resting periods becomes altered.

On the other hand, regarding the environmental enrichment, in this study its use was essential to stimulate an adequate behavior in the owls. Owls 3, 4, 5, and 6 showed affiliative interactions and behaviors such as flying and bathing.

To this respect, Rasidi and Cornejo (20) mentioned that, in order to generate desirable behavioral and health situations for the captive birds, the individuals that are confined in the same space must be, preferably, of the same species and compatible. Moreover, whenever possible, comparisons must be made to detect changes in their behavior, both in isolated and in grouped animals.

Regarding feeding in this study, the owls in the large enclosures that were fed at night, showed the behavior of looking for prey during the day and night. On the contrary, this behavior was not possible in Owls 1 and 2, as they only received food directly during the day hours, without looking for prey. To this respect, and regarding this foraging behavior, Fernández et al (16) mention that animals need to dedicate great deal of their time to this activity, and that the feeling of hunger is directly related to the internal stimulus that appears during the search for food.

With respect to the reproductive behavior of the females in this study, the fecal progesterone metabolites concentrations were lower in Owls 1 and 2, in comparison with Owls 3, 4, and 5. In these latter, estradiol and corticosterone increased during May through August, which could be related to the reproductive period, however, no differences were found among these months.

Almeida et al (6) indicated that for reproductive behaviors to manifest under captivity, essential elements are required, such as: promoting the adequate conditions in the enclosures, introduction of accessories for the enrichment, and providing a balanced diet.

Regarding the corticosterone concentrations in the Owls 3, 4 and 5, it would have to be

considered that, as cited by Schoenle et al (21), there was a natural increase because of stress. Due to stimuli such as sexual and reproductive activity, there is higher energy demand that is necessary to mobilize the resources that must be invested in these activities to enhance the reproductive capacity, which results in a higher demand for glucocorticoids. In this context, Puehringer-Sturmayer et al (22) observed that, in the great horned owl (*Bubo virginianus*), corticosterone levels increased during the breeding season in comparison with the non-breeding season.

As for animal welfare, in this study there were determinant factors for the welfare levels obtained: the dimensions and the conditions of the enclosures or housings, the type and way of feeding, and the absence or presence of shelter. To this respect, Estay-Stange and Oidor-Méndez (23) pointed out the great importance of feeding on the keeping of captive raptors, being of high relevance the time of feeding, which must be at sunset or night, with water available *ad libitum*. Moreover, it has to be kept in mind that the enclosures or housings must have the adequate dimensions, even though there are no official regulations on the minimal conditions.

In this study, the owls that had regular welfare were either caged or perched, with reduced enclosures or spaces, with no shelter nor water *ad libitum*, and being fed only diurnally, unlike the owls that had excellent welfare, which were in large enclosures that were designed according to their needs (9), which allowed them to perform activities such as flying and bathing.

Another relevant aspect is the keeping of records on the origin and health background of the animals, since it is necessary to keep them updated for each animal (17). There were no records for the individuals that had regular welfare, whereas there were records with information on the arrival and veterinary check-ups for the animals housed in large enclosures.

Kapusta et al (24) consider it essential to provide welfare to captive wild animals because, depending on whether it is good or poor, they will be able to have a good or poor life quality. In addition, the training of the handlers is of paramount importance, as it has been observed that there is a great influence on the relationship handler-animal with the behavior of the animals (25).

In the interviews in this study it was observed that the handlers of Owls 1 and 2, which were exhibited to the public, had received no training for it, and not even any information on the adequate handling of these birds. In fact, as part of the evaluation during the physical exam it was observed that both birds, which were in a cage and on a perch, had damaged plumage and overgrown claws and beak.

As conclusion and recommendations, in nocturnal raptors under captivity, such as the owls, diurnal exhibition and inadequate conditions in the facilities promote the presence of undesirable behaviors that can affect their welfare. Therefore, the application of measures or enrichments such as making larger enclosures, nocturnal feeding,

and housing the owls in pairs, female and male, or two females, must be considered to decrease the negative effect of captivity and increase the welfare of the owls.

Conflict of interests

We the authors of this investigation declare that there is no conflict of interests regarding the publication of this manuscript.

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