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Effect of Seasonal Variations on the Behavior of Captive Lions (*Panthera leo*) and Tigers (*Panthera tigris*)

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ABSTRACT

Lions (*Panthera leo*) and tigers (*Panthera tigris*) are nocturnal animals. Opportunistically, they may hunt during the daytime in the wild. In captivity, they spend most of their time sleeping, resting, or pacing and face different conditions seasonally as compared to their natural habitat. It alters their activity and may reduce agility. By studying the impact of seasonal variation on captive behavior, the temperature and other seasonally dependent factors can be optimized in the zoo. This study was designed to investigate the effect of summer and winter seasons on adult and juvenile carnivores' captive behavior. The study was conducted in Lahore Zoological Garden, Pakistan, documenting the cage area and behavioral ethogram. The subjects were two African lions, six African lionesses, four lion cubs, two Bengal tigers, and two Bengal tigresses which were observed for auditory, aggression, feeding, moving, resting, and excretory behaviors by scan sampling method. The winter data were collected in February and summer data were collected in June for ten days each month in three sessions (8:00-10:00 am, 12:00-2:00 pm, and 4:00-6:00 pm). A total of 60 h of data were collected for each season. The activity budget of animals for both seasons was compared and the alteration in any behavioral category was analyzed. The results showed that the significantly altered behavior in all animal groups was moving (p<0.05). Seasonal variation had a significant impact on the resting (p<0.05) of Bengal tigers, Bengal tigresses, and lion cubs. Auditory behavior (p<0.05) of Bengal tigers and lion cubs while aggressive behavior (p<0.05) of Bengal tigers significantly varied in the summer and winter seasons. All other behaviors were not significantly affected by the seasonal change in each of the carnivore groups. This study revealed the impact of seasonal variations on the behavior of captive carnivores and can be beneficial to optimize captive conditions.

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Authors' Contribution
NA and ZA conceptualized the study. NA gathered data from the field and information about the animals. NA and NN analyzed the data. NA and RA drafted the manuscript. ZA reviewed and improved the manuscript.

Key words
Activity, Captivity, Captive behavior, Carnivores, Seasonal variations

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INTRODUCTION

Animal behavior is a reaction to an animal's environment in the wild and captivity. It is dynamic and multifactorial (Quirke *et al*., 2012). Any change in the ecosystem has an impact on carnivore population density (Wildt *et al*., 2001). They show remarkable social learning and their generation time is comparatively long, revealing their difficult recovery from decline. It is the main reason for their ex-situ and in-situ conservation programs in zoos. Captive-born carnivores remain deprived of learning social behaviors like hunting and may show captivity adaptations (Soorae and Price, 1997). Cognitive and behavioral complexity is related to environmental complexity (Marino *et al*., 2020). Reduced space, visitors presence, and lack of mental and physical stimuli provoke chronic stress (Almeida *et al*., 2018). Limitations in the behavioral needs of captive large felids can lead them towards stereotypic behaviors like pacing (Mason *et al*., 2007).

The major captivity hurdles for animals are decreased rate of conception and survivorship challenges (Clubb and Mason, 2003, 2007). To cope with these challenges, a living system always struggles to keep a steady state i.e., homeostasis and a daring factor for it is a stressor (Michelson *et al*., 1995). These stressors harm the animal in numerous ways. For instance, loud sounds have an opposing impact on blood pressure and cardiovascular rhythm in humans (Hagerman *et al*., 2005) and in animals (Salvetti *et al*., 2000). Many animals including tigers are also able to detect infrasounds. The persistent fear in animals can arise due to the provision of highly contrasting light and dark areas (Grandin and Johnson, 2005) and the

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long prevalence of photoperiods affects the enzymatic metabolic activities of the nervous system and may suppress circadian rhythm (Ikeda *et al*., 2000).

In addition to it, seasonal fluctuation in captivity provides the animals with another stressor, 'the temperature' that influences behavioral responses and interactions (Morgan and Thromborg, 2007). Large cats in captivity encounter seasonal variations which may not resemble their native habitat and they may show different behavior than in the wild (Margulis *et al*., 2003). The energetic needs also vary in the wild and captive environment (Guivas *et al*., 2021). In addition, a wild environment allows the animals to escape from harsh weather as it is provided with many complex environmental enrichments like trees, large areas, bushes, rocks, etc. While a captive environment is restricted (Resende *et al*., 2011) and does not provide these luxuries (Morgan and Thromborg, 2007), hence, the captive animal may behave accordingly. Large cats are an important part of the animal collection in a zoo (Mohapatra *et al*., 2014). So, a well-managed zoological garden attempts to conserve the species' natural and typical behaviors (Rabin, 2003) by trying to make the captive environment resemble the wild.

To provide a tool for carnivores' conservation and welfare, this study was designed to study the captive behavior of African lions (*Panthera leo*) and Bengal tigers (*Panthera tigris*) in Lahore Zoo with the following objectives (1) to investigate the effect of seasonal variations on the activity budget of both species, (2) to highlight the presence of abnormal or stereotypic behavior, and (3) to monitor the activity budget of captive born lion cubs.

MATERIALS AND METHODS

Study site

The study site was Lahore Zoological Garden. Lahore is a city in Pakistan that features five seasons: foggy winters last from 15 November to 15 February, spring season from 16 February to 15 April, and the summer season (with heat waves, dust, and rainy monsoon) July to 16 September and autumn from 16 September to 14 November. Lahore Zoo was established in 1872 and is among the four oldest zoos in the world (Sikander *et al*., 2015).

Study subjects

The study subjects were two male African lions, six female African lions, one male Bengal brown tiger, one female Bengal brown tiger, one male Bengal white tiger, one female Bengal white tiger (Table I), and four lion cubs (Table II).

Enclosures

African lions (*Panthera leo)* have been provided a cage size of 458 m² with 8 individuals inhabiting it. Bengal brown tigers (*Panthera tigris*) have been provided a cage size of 747.8 m² with two individuals. Bengal white tigers have been provided with an enclosure size of 747.8 m² with two individuals.

During the study, subject 1 and subject 5 were housed in an indoor area where they were on display to the public (on exhibit). Subjects 2, 6, and 7 were housed together and were provided with both indoor and outdoor areas. Subject 4 with its three cubs was housed in an indoor area with a holding. The indoor area was on exhibit and provided with a wooden log. In summer, three cubs were housed in another in-door and on-exhibit area with a holding on the rear side. Subject 8 was housed with one lion cub in an in-door on-exhibit area while subject 3 was kept isolated outdoors being old and injured (Table I).

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Table I. Detailed information about the study subjects.

Animal	Sex	Subject	Age at study started	Birth and rearing	Reproduction
African lion	Male	1	8 years	Captive-born, hand raised	Sire of cubs
African lion	Male	2	12.5 years	Not recorded, hand raised	Sire of cubs
African lion	Female	3	16.5 years	Captive-born, hand raised	Dam of cubs
African lion	Female	4	10 years	Captive-born, parental raised	Dam of cubs
African lion	Female	5	4 years	Captive-born, parental raised	None
African lion	Female	6	4 years	Captive-born, parental raised	Dam of cubs
African lion	Female	7	4 years	Captive-born, parental raised	Dam of cubs
African lion	Female	8	1.5 year	Captive-born, parental raised	None
Bengal tiger	Male	9	4 years	Captive-born, parental raised	None
Bengal tiger	Female	10	1.5 year	Captive-born, parental raised	None
Bengal tiger	Male	11	4 years	Captive-born, parental raised	Sire of cubs
Bengal tiger	Female	12	6 years	Not recorded, hand raised	None

Table II. Detailed information on lion cubs.

Lion cubs	Sex	Age at the study started	Birth and rearing
Cub 1	Male	10 months	Captive-born, hand raised
Cub 2	Male	6 months	Captive-born, parental raised
Cub 3	Female	6 months	Captive-born, parental raised
Cub 4	Female	6 months	Captive-born, parental raised

Subject 9 (brown Bengal tiger) was housed in an indoor cage with a small holding on the rear side and on-exhibit all the time where it remained solitary throughout the study. Subject 10 was also housed solitary but provided the access to an outdoor area as well. Subjects 11 and 12 were placed together in the indoor area (Table I).

Each indoor area was provided with a tiled floor, a wood log, water pool in summer and winter while air cooler and ice blocks were only summer enrichments. The outdoor area was furnished with rocks, grassy land, wood logs, a water pool, and trees (Fig. 1). Food given to the lions and tigers consisted of mutton, chicken, and beef for adults, while only chicken for lion cubs.

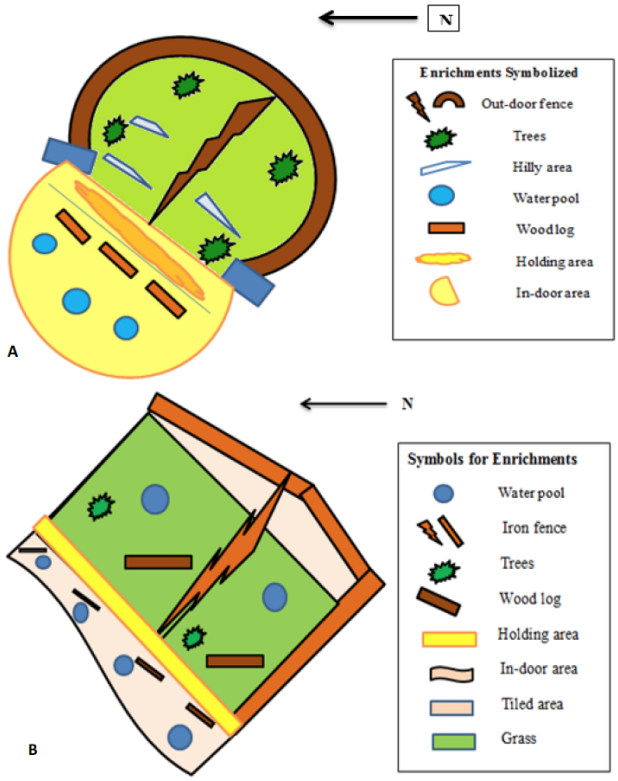

Fig. 1. Symbolic representation of lion (A) and tiger (B) enclosures in Lahore Zoo.

Data collection

Data was collected by the scan sampling method. It is a method in which the animal's behavior is recorded after a short time interval and then the observer moves to take the behavioral observation of the next animal. The observer takes the scans very quickly or after regular intervals (Man, 1999). Each large cat was observed for three sessions of two h with instantaneous scans of the behavior of all individuals in a housing condition at 5-min intervals. Behavioral categories were observed following the ethogram (Table III).

The data were collected in the winter (February 2016) and summer (June 2016) seasons for 10 days each month. The temperature remained from 15°C to 21°C in February and from 35°C to 42°C in June.

The data were collected in three sessions a day, between 8:00-10:00 am, between 12:00-2:00 pm, and between 4:00-6:00 pm. All subjects were observed for equal amounts of time. The large felids were observed from public viewing areas and a total of 120 h of data were collected (60 h in each season).

The behavioral patterns of all study subjects were summarized and their activity budget was recorded. The activity budget of all studied male lions was considered to be one category and the same was applied to lionesses, lion cubs, tigers, and tigresses. All scans of each behavioral category under the behavioral ethogram (Table III) were converted into a percentage and a total activity budget for summer and winter was obtained.

Table III. Behavioral ethogram.

Behaviors	Description
Resting	Animal resting while lying down and sitting with no movements, by keeping eyes open or closed
Feeding	
(1) Drinking	Drinking water
(2) Eating	Using canines, food taking in or grinding
Moving	Moving to a specific direction or repeated movements (pacing)
Excretion	
(1) Urinating	Urine discharge may be related to territory demarcation
(2) Defecating	Fecal discharge
Auditory	Making vocalizations
Aggression	Ready to attack or feeling of anger or violent behavior

Statistical analysis

The statistical significance of the results was analyzed by SPSS version 26. A normality test was applied to the data collected by each animal group separately.

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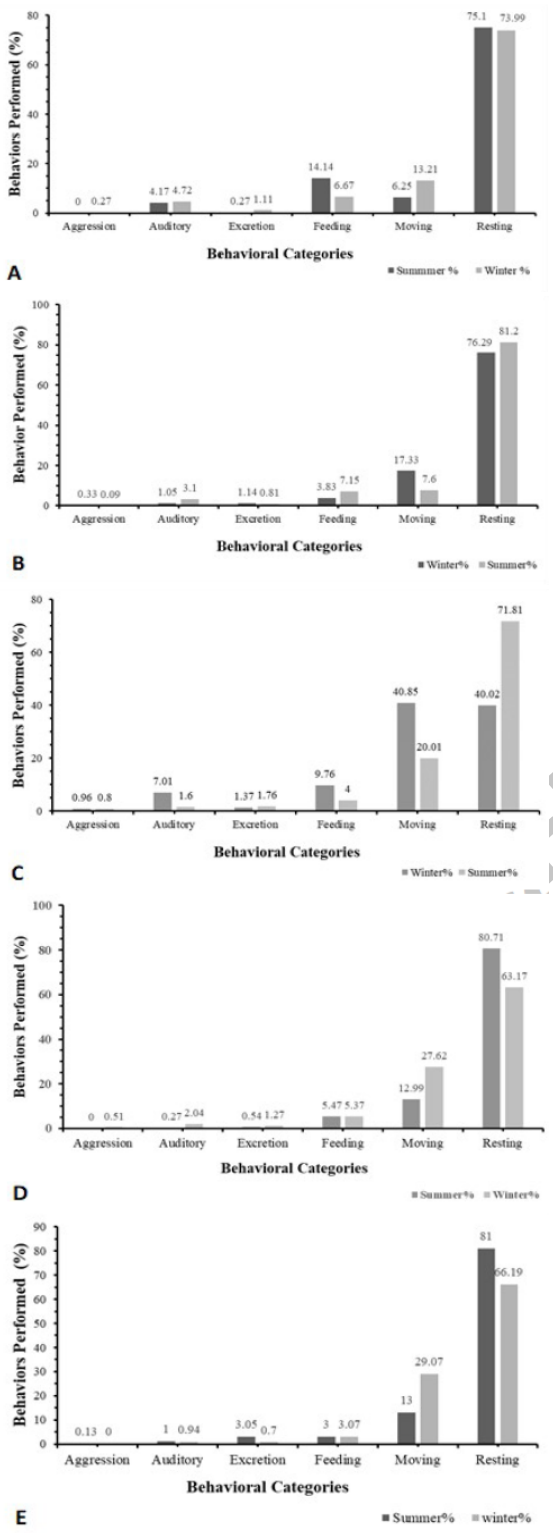

Fig. 2. Comparison of summer and winter activity budgets of lion (A), lioness (B), lion cubs (C), tigers (D) and tigresses (E).

A paired sample t-test was applied for statistical analysis of normally distributed and the Wilcoxon rank test for non-normally distributed data.

RESULTS

Lions

All lions spent most of their time inactive in captivity. Their inactivity, however, can be related to the day sessions. They spent most of their time resting during the noon sessions (12:00 pm to 2:00 pm) and remained comparatively active during the morning (8:00 am to 10:00 pm) and evening sessions (4:00 pm to 10:00 pm).

The male lions showed little movement during the study but this behavior was increased in winter (13.21%) than in summer (6.25%). Feeding was found to be decreased (14.14% to 6.67%) in winter (Fig. 2A). Lions roared and made low-frequency vocalization during morning and evening sessions in both seasons, this activity was also found to increase from 4.17% to 4.72% in winter. There was a little decrease in resting from 75.1% to 73.99% in winter.

A paired sample t-test revealed that seasonal variation had a significant impact on moving (df=3, t=-6.95, p=0.006), while aggression (df=3, t=-2.82, p=0.067), auditory (df=3, t=-0.49, p=0.660), feeding (df=3, t=1.09, p=0.345), resting (df=3, t=0.21, p=0.850), and excretion (df=3, t=-2.83, p=0.066) were not significantly affected by the seasonal variation.

Lionesses

The study revealed that there was a similarity in lions' and lionesses' behavior. The lionesses spent most of the time resting and there was an increase in summer from 76.29% to 81.2%. Moving was observed to have increased from 7.6% to 17.33% in winter. Feeding increased in summer from 3.83% to 7.15% and auditory behavior was observed to increase in summer from 1.05% to 3.1% (Fig. 2B).

A wilcoxon rank test suggested that the feeding (N=4, p=0.715) behavior was not significantly affected. A paired sample t-test showed that the seasonal change did not significantly alter the aggression (df=3, t=-2.64, p=0.078), auditory (df=3, t=1.38, p=0.262), resting (df=3, t=1.09, p=0.357), and excretory (df=3, t=-0.97, p=0.403) behaviors. Only moving (df=3, t=-9.87, p=0.002) behavior was found to be significantly affected by the seasonal change.

Lion cubs

The lion cubs were found to be very active and agile during the study as they all were captive-born. The cubs showed highly contrasting resting behavior in both

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seasons as resting was found to increase from 40.02% to 71.81% in summer (Fig. 2C). Just like adults, their moving behavior was also recorded to have decreased from 40.85% to 20.01% during summer observations. Vocalization increased in winter from 1.6% to 7.01%. The juveniles were found to be more affected by seasonal variation as compared with the adult lions.

A paired sample t-test (N=4, df =3) revealed a significant impact of seasonal variations on auditory (df=3, t=-20.20, p=0.000), moving (df=3, t=-39.39, p=0.000), and resting (df=3, t=9.45, p=0.003) behaviors while aggression (df=3, t=-0.13, p=0.907), feeding (df=3, t=-1.93, p=0.148), and excretion (df=3, t=0.12, p=0.912) were not significantly affected by the seasonal change.

Tigers

Male tigers were found to be active during winters as their resting was reduced from 80.71% to 63.17% in winters. It is considerable, that their increased winter moving (from 12.99% to 27.62%) included stereotypic pacing which was also observed in Bengal brown tiger. The tigers almost feed for the same duration of the day, 5.4% in summer and 5.37% in winter. The tigers made more vocalizations in winter 2.04% than in summer 0.27% (Fig. 2D).

A paired sample t-test suggested that there was a significant impact of seasonal variation on auditory (df=3, t=-19.18, p=0.000), aggression (df=3, t=-11.64, p=0.001), moving (df=3, t=-15.54, p=0.001), and resting (df=3, t=5.92, p=0.010) behaviors of tigers. Feeding (df=3, t=0.04, p=0.970) and excretion (df=3, t=-2.14, p=0.122) were not significantly affected by seasonal alteration.

Tigresses

Two tigresses understudy; they spent most of their captive time resting. Their resting behavior was found to be reduced from 81% to 66.19% in winter. Their moving increased in winter (29.07%) as compared with summer (13%). There was not a considerable effect of seasonal variations on feeding and auditory behaviors. Excretion was found to increase in summer from 0.7% to 3.05% (Fig. 2E).

By applying a paired sample t-test, a significant impact of seasonal variation was revealed on resting (df=3, t=3.87, p=0.030) and moving (df=3, t=-3.63, p=0.036) behaviors while auditory (df=3, t=-1.80, p=0.169), aggression (df=3, t=1.39, p=0.256), excretion (df=3, t=0.71, p=0.529), and feeding (df=3, t=-0.011, p=0.992) behaviors were not significantly affected.

DISCUSSION

Large felids show alteration in their activity budget during the day. They spend most of their mid-day time inactive in the wild and captivity (Jackson, 2015). In captivity, the peak zoo-visitor h are also spent showing the same behavior. On the other hand, visitors find active animals more interesting and attractive (Morgan and Tromborg, 2007).

All the adult lions and tigers spent most of their time resting during this study but the resting behavior was observed to be prolonged in the case of female lions because subject 3 who was 16.5 years old and had a wound in the paw, spent most of the time resting and was kept isolated in an enclosure. All lionesses were active as compared to males (Dunston *et al*., 2017) but the addition of subject 3 (the older one) affected the results.

The effect of seasonal variation and stress of increased temperature was more prominent in tigers, as they are a prominent species for showing stereotypic pacing in captivity (Sazokalski *et al*., 2012). Living solitary with large space and live prey availability are the luxuries of the wild habitat of tigers. In captivity, they are mostly provided with reduced area and varied seasons. Additionally, they expect to be active during visitors presence (Morgan and Tromborg, 2007). In our study, tigers were found to be stressed. All male and female tigers showed more or less pacing. But subject 9 showed continuous stereotypic pacing from morning to evening sessions in summers and it was reduced in winters. This tiger was not a zoo breed and continuous on-exhibit made it frustrated (Morgan and Tromborg, 2007). This tiger was kept solitary (in a small indoor enclosure and was never allowed to outdoors) due to its past attacking attempts on visitors and maybe that restricted enclosure in addition to increased temperature was the reason for its pacing behavior in summer.

The increased auditory behavior of all the studied animals (except male tigers and lion cubs) was found to increase in summer due to the provision of ice blocks. The animals after licking them used to make low or medium-frequency vocalizations to maintain their oral cavity temperature. The reason for more winter vocalization of male tigers is still unknown. The animals' thermoregulatory behavior was observed in summer when they used to lick the ice and kept themselves wet in the water pool. The water pool with clean water was a tool for carnivores' welfare in summer (Biolatti *et al*., 2016).

The lion cubs were younger in winter causing them to make more vocalizations during their natural learning process and due to visitors' interaction. Their resting behavior was increased in summer as compared to winter because, in summer, they had become grown up and started a tendency of behavioral adoption to that of adults. They kept themselves engaged in wall stretching and interacting with visitors. Among them, the hand-raised lion cub was

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found to be more interactive with humans as compared to mother-raised cubs. While mother-raised cubs showed more confidence and aggressive behavior toward the visitors. They showed more diversified behaviors as they were housed with their mother lioness (Ncube and Ndagurwa, 2010). All these observations suggested that some of the influencing factors in captivity include: Social status, environmental enrichments, and seasonal variations. Our study can be a good tool for zoo management to quantify or minimize the stereotypic behaviors (in summer, due to increased temperature) and to optimize the seasonally dependent captive environmental conditions of lions and tigers.

CONCLUSION

African lions and Bengal tigers are considered to be one of the most interesting animals in any zoological garden. Their status in captivity is a matter of concern for conservation ecologists. Animals' prolonged resting and being aimless in captivity, lead them towards stereotypic or abnormal behaviors which zoo managers always try to minimize. Aiming to evaluate the impact of seasonal variation on the captive behavior of two carnivore species, African lions and Bengal tigers were selected. The results showed that the increased temperature in summer causes increased resting behavior and lesser behavioral diversity. On the other hand, winters made the animals agile and resulted in the reduction of resting behavior and stereotypic pacing. This study suggests that the carnivores' agility and behavioral diversity in captivity are related to seasonal variation which is helpful to optimize the captive conditions for the well-being of the captive lions and tigers.

RECOMMENDATIONS

The frequent reproduction of lions in Lahore Zoo and the health status of lion cubs indicates the appreciable steps by zoo management for the well-being of the species. But it can be recommended that the provision of live animals (preferably the smaller ones to avoid risks) for feeding in the outdoor area may enhance behavioral diversity and may conserve their wild behaviors. It may result in increased metabolic rate, high cognition, and enhanced behavioral diversity.

Secondly, by finding pacing behavior in one of the tigers, it is recommended that its solitary confinement can be altered by sending it to a national park or by providing it with multiple environmental enrichments to recover from stereotypic pacing.

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Ethical statement

No animal was harmed or disturbed during this research.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Almeida, A.C., Palme, R. and Moreira, N., 2018. How environmental enrichment affects behavioral and glucocorticoid responses in captive blue-and-yellow macaws (*Ara ararauna*). *Appl. Anim. Behav. Sci*., **201**: 125-135. https://doi.org/10.1016/j.applanim.2017.12.019

Biolatti, C., Modesto, P., Dezzutto, D., Pera, F., Tarantola, M., Gennero, M.S., Maurella, C. and Acutis, P.L., 2016. Behavioural analysis of captive tigers (*Panthera tigris*): A water pool makes the difference. *Appl. Anim. Behav. Sci.,* **174**: 173-180. https://doi.org/10.1016/j.applanim.2015.11.017

Clubb, R. and Mason, G., 2003. Captivity effects on wide-ranging carnivores. *Nature*, **425**: 473–474. https://doi.org/10.1038/425473a

Clubb, R. and Mason, G.J., 2007. Natural behavioral biology as a risk factor in carnivore welfare: How analyzing species differences could help zoos improve enclosures. *Appl. Anim. Behav. Sci.,* **102**: 303–328. https://doi.org/10.1016/j.applanim.2006.05.033

Dunston, E.J., Abell, J., Doyle, R.E., Kirk, J., Hilley, V.B., Forsyth, A., Jenkins, E., McAllister, D. and Freire, R., 2017. Investigating the impacts of captive origin, time and vegetation on the daily activity of African lion prides. *J. Ethol*., **35**: 187-195. https://doi.org/10.1007/s10164-017-0508-x

Grandin, T. and Johnsson, C., 2005. *Animals in translation*. Scribner, New York, NY.

Güivas, B.R., Jawor, J.M. and Wright, T.F., 2021.

Seasonal variation in fecal glucocorticoid levels and their relationship to reproductive success in captive populations of an endangered parrot. *Diversity*, **13**: 617. https://doi.org/10.3390/d13120617

Hagerman, I., Rasmanis, G., Blomkvist, V., Ulrich, R., Eriksen, C.A. and Theorell, T., 2005. Influence of intensive coronary care acoustics on the quality of care and physiological state of patients. *Int. J. Cardiol.,* **98**: 267–270. https://doi.org/10.1016/j.ijcard.2003.11.006

Ikeda, M., Dagara, M. and Inoue, S., 2000. Continuous exposure to dim illumination uncouples temporal patterns of sleep, body temperature, locomotion and drinking behavior in the rat. *Neurosci. Lett.,* **279**: 185–189. https://doi.org/10.1016/S0304-3940(99)00943-X

Jackson, R.M., 2015. HWC ten years later: Successes and shortcomings of approaches to global snow leopard conservation. *Hum. Dimens. Wildl.,* **20**: 310-316. https://doi.org/10.1080/10871209.2015.1005856

Man, J., 1999. Behavioral sampling methods for cetaceans: A review and critic. *Mar. Mammal. Sci.,* **15**: 102-122. https://doi.org/10.1111/j.1748-7692.1999.tb00784.x

Margulis, S.W., Hoyos, C. and Anderson, M., 2003. Effect of felid activity on zoo visitor interest. *Zoo Biol.,* **22**: 587–599. https://doi.org/10.1002/zoo.10115

Marino, L., Rose, N.A., Visser, I.N., Rally, H., Ferdowsian, H. and Slootsky, V., 2020. The harmful effects of captivity and chronic stress on the well-being of orcas (*Orcinus orca*). *J. Vet. Behav*., **35**: 69-82. https://doi.org/10.1016/j.jveb.2019.05.005

Mason, G., Clubb, R., Latham, N. and Vickery, S., 2007. Why and how should we use environmental enrichment to tackle stereotypic behavior? *Appl. Anim. Behav. Sci*., **102**: 163–188. https://doi.org/10.1016/j.applanim.2006.05.041

Michelson, D., Licinio, J., and Gold, P.W., 1995. Mediation of the stress response by the hypothalamic-pituitary-adrenal axis. In: *Neurobiological and clinical consequences of stress: From normal adaptation to PTSD* (eds. M.J. Friedman, D.S. Charney and A.Y. Deutch). Lippincott-Raven Publishers, Philadelphia, PA, pp. 225–238.

Mohapatra, R.K., Panda, S. and Acharya, U.R., 2014. Study on activity pattern and incidence of stereotypic behavior in captive tigers. *J. Vet. Behav*., **9**: 172-176. https://doi.org/10.1016/j.jveb.2014.04.003

Morgan, K.N. and Tromborg, C.T., 2007. Sources of stress in captivity. *Appl. Anim. Behav. Sci.,* **102**: 262–302. https://doi.org/10.1016/j.applanim.2006.05.032

Ncube, S. and Ndagurwa, H.G.T., 2010. Influence of social upbringing on the activity pattern of captive lion Panthera leo cubs: Benefits of behavior enrichment. *Curr. Zool*., **56**: 389-394. https://doi.org/10.1093/czoolo/56.4.389

Quirke, T., O'Riordan, R.M. and Zuur, A., 2012. Factors influencing the prevalence of stereotypical behavior in captive cheetahs (*Acinonyx jubatus*). *Appl. Anim. Behav. Sci.,* **142**: 189–197. https://doi.org/10.1016/j.applanim.2012.09.007

Rabin, L.A., 2003. Maintaining behavioural diversity in captivity for conservation: Natural behaviour management. *Anim. Welf*., **12**: 85–94. https://doi.org/10.1017/S0962728600025409

Resende, L.S., Gomes, K.C.P., Andriolo, A., Genaro, G., Remy, G.L. and Junior, V.A.R., 2011. Influence of cinnamon and catnip on the stereotypical pacing of oncilla cats (*Leopardus tigrinus*) in Captivity. *J. Appl. Anim. Welf. Sci*., **14**: 247–254. https://doi.org/10.1080/10888705.2011.576981

Salvetti, F., Chelli, B., Gesi, M., Pellegrini, A., Giannaccini, G., Lucacchini, A. and Martini, C., 2000. Effect of noise exposure on rat cardiac peripheral benzodiazapine receptors. *Life Sci*., **66**: 1165–1175. https://doi.org/10.1016/S0024-3205(00)00422-7

Sikander, S.K., Ali, Z., Nemat, A., Ahmad, S., Hussain, Z., Saleem, K. and Khan, M.N., 2015. Diet provision for zoo animals in captive conditions of Lahore Zoo, Pakistan. *J. Anim. Pl. Sci.,* **25**: 493-499.

Soorae, P.S. and Price, M.R., 1997. Successful re-introductions of large carnivores what are the secrets? *Nature*, **425**: 473–474.

Szokalski, M.S., Litchfield, C.A. and Foster, W.K., 2012. Enrichment for captive tigers (Panthera tigris): Current knowledge and future directions. *Appl. Anim. Behav. Sci.,* **139**: 1-9. https://doi.org/10.1016/j.applanim.2012.02.021

Wildt, D.E., Howard, J. and Brown, J., 2001. Role of reproductive sciences in carnivore populations. In: *Carnivore conservation, conservation biology* (eds. J.L. Gittleman, S.M. Funk, D. Macdonald and R.K. Wayne), vol. 5. Cambridge University Press, Cambridge. pp. 359–371.

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