

## Factors influencing the behaviour of common leopard (*Panthera pardus*) in captivity

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### Abstract

Understanding the factors influencing the enrichment of the behaviour of the common leopard (*Panthera pardus*) in a captive environment is crucial for promoting their well-being and enhancing conservation efforts. Lack of species-specific enrichment can lead to stress, disturbances, and altered behavioural patterns, including developing stereotypic behaviours. This study aims to assess the effect of different types of enrichment on the behaviour and welfare of four individual common leopards housed at the National Zoological Park, New Delhi. This study was conducted in two phases: the first phase i.e. pre-enrichment phase, in which the enclosures of leopards were studied with the existing infrastructure and facilities, and in the second phase, the enrichment was introduced in the leopard enclosures i.e. post-enrichment phase. We used focal and scan sampling methods for data collection during Phase I (Pre-enrichment phase) and Phase II (Post-enrichment). This study provides valuable insights into the relationship between different types of enrichment and behaviour in common leopards in captivity. The main results of the study highlighted that with no enrichment, all leopards exhibit more inactive and more stereotypic behaviour than in the presence of enrichment. However, with the use of different enrichment interventions, the leopard exhibits more active behaviour. This study will in turn form a basis for the development of effective management approaches to minimize stress and disturbances, enhance the welfare of the studied species, and support conservation efforts in zoos across the country.

**Keywords:** activity pattern, enrichment, inactive, stereotypic, sustainability

## Introduction

Zoological Parks are recognized centers of education and conservation globally (Loh et al., 2018; Hutchins et al., 1995). In the past decades, zoos have been striving to ensure and improve animal welfare, and making significant progress in species conservation. However, in captivity, the animals are deprived of their natural habitat (Keulartz, 2023). Thus, captivity deprives animals of the necessity and opportunity to perform their instinctive behaviour such as finding food i.e. prey, and evading enemies i.e. predators, which inevitably leads to boredom (Frazer, 2008). To overcome the problem of boredom, there is a need to implement ‘occupational therapy’, according to Heine Hediger, known as the ‘father of zoo biology’. “The captive animal must be given a new interest in life, an adequate substitute for the chief occupations of freedom” (Hediger, 2013; Keulartz, 2023).

India has 154 zoos (as of 2022) which are categorized into large, medium, small, mini, and rescue centers (CZA, 2023). The National Zoological Park, New Delhi (NZP) is one of the large category zoos recognized by the Central Zoo Authority having an area of 214 acres housing 96 species including mammals, reptiles, and, birds. Among large carnivores, the National Zoological Park, New Delhi housed Bengal tigers (normally coloured and white), Asiatic lions, common leopards, and jaguars. Most of the carnivores housed at NZP are listed under Schedule I of the Wild Life (Protection) Act, 1972. Therefore, the need for conserving the species in captive conditions for its long-term survival is required through planned and effective zoo management strategies. The behaviour assessment of carnivores in captive conditions for its conservation needs to be studied from time to time so that the naturalistic conditions may be provided to the animals and their natural behaviour may be conserved.

Understanding the factors that influence their behaviour, including activity levels, inactivity, and stereotypic behaviours, is crucial for providing appropriate care and creating enriching environments that promote their well-being (Shyne, 2006). Environmental enrichment of captive animals has been defined as “an animal husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being” (Shepherdson, 1998). The research carried out by Markowitz at the Portland Zoo (U.S.A.) in the 1970s may be the first use of environmental enrichment techniques (Markowitz, 1978).

The National Zoological Park, New Delhi (NZP), houses four common leopards (*Panthera pardus*), each exhibiting unique behavioural patterns and responses to their captive environment

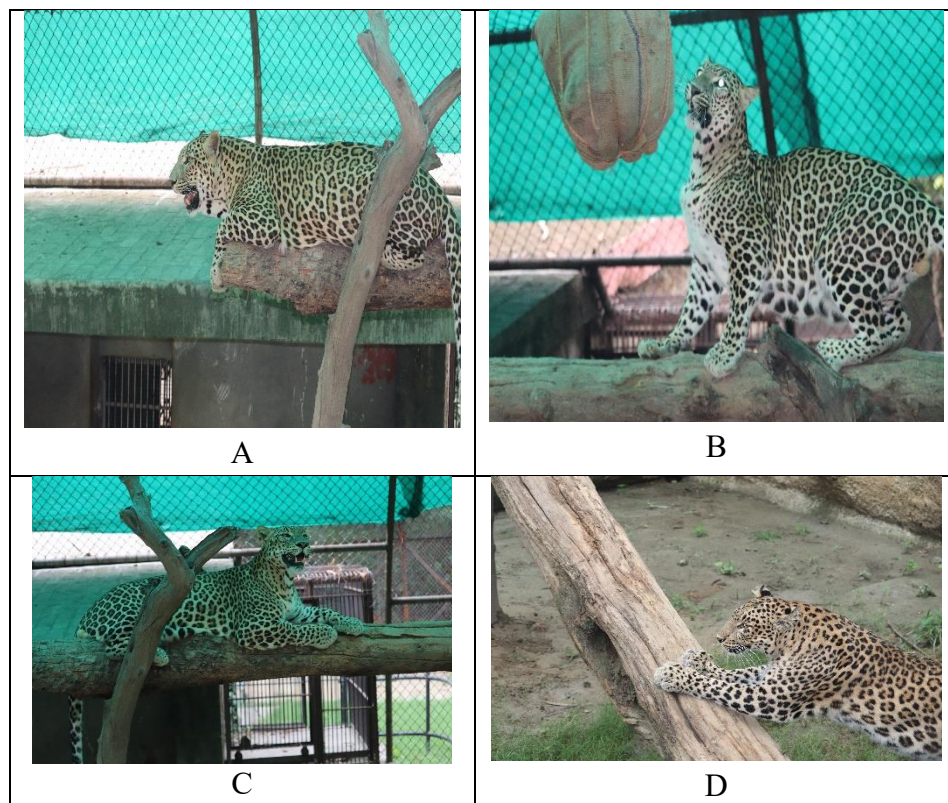
(Avni et al., 2020). The evaluation of factors affecting the active, inactive, and stereotypic behaviour of leopards in the NZP focuses on examining the impact of enrichment interventions on their behaviour. Enrichment refers to the provision of stimuli and activities that promote natural behaviours, cognitive engagement, and physical exercise (Hosey & Skyner, 2007). The pre-enrichment and post-enrichment phases allow for a comparative analysis of how these interventions influence the behavioural patterns of the animals (Mohapatra et al., 2014). The benefits of different enrichment techniques on captive animals have also been shown by Kusumaningsih & Rosiana (2023). The combination of different types of enrichment intervention has been noted to be having an impact on the behavioural and physiological welfare of captive Asiatic lions (*Panthera leo persica*) at Sakkarbaug Zoological Park, Junagarh, Gujarat (Goswami et al., 2021). In the case of three small felid species (*Caracal*, *Bush cat*, *Ocelot*), the effects of two additional environmental enrichments have impacted the behaviour and faecal cortisol levels of these species in captivity (Normando et al., 2023).

Factors such as the type of enrichment, frequency of implementation, social interactions, and habitat design also play crucial roles in shaping the behaviour of captive leopards (Jenny & Schmid, 2002). Active behaviours, characterized by natural movement, exploration, and foraging, are indicators of a stimulated and healthy animal (Pitsko, 2003). Inactive behaviours, such as rest and sleep, are vital for maintaining physiological functions. Stereotypic behaviours, repetitive and seemingly purposeless actions, are of concern as they may reflect suboptimal captive conditions or psychological distress (Mallapur & Chellam, 2002).

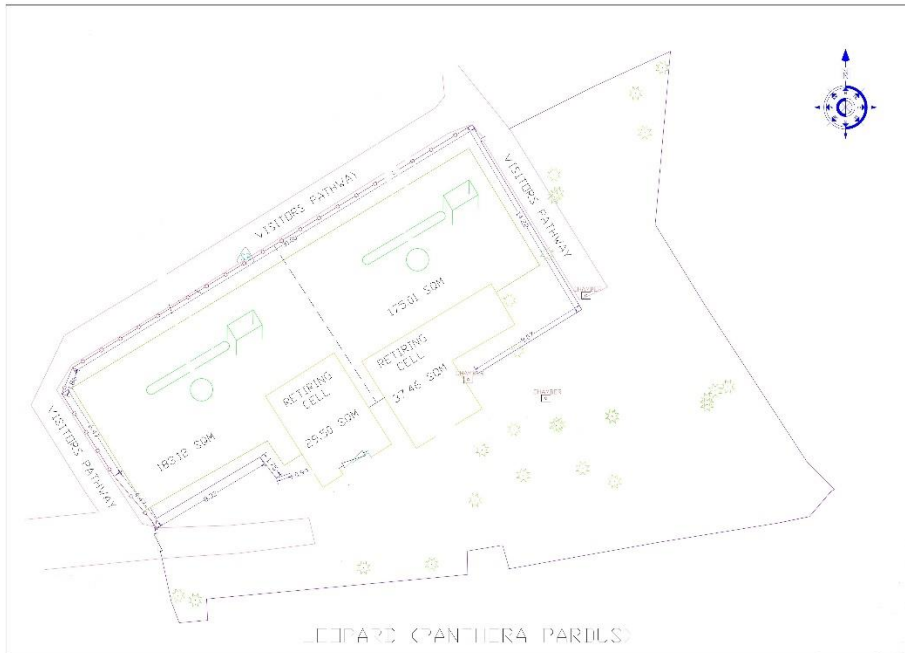
This study aims to investigate the factors that influence the active, inactive, and stereotypic behaviours of leopards in the NZP, specifically comparing the pre-enrichment and post-enrichment phases. Through systematic observations, behavioural assessments, and data analysis, the present study identifies the effects of enrichment interventions on the behaviour of these animals. The findings from this study will provide insights into the effectiveness of enrichment strategies in promoting natural behaviours and reducing stereotypic behaviours in captive leopards. By identifying successful enrichment practices, the NZP may enhance the well-being and behavioural expression of these animals. Moreover, this study will contribute to the broader understanding of effective enrichment approaches for leopards in other zoological parks and conservation settings. Overall, this research will contribute to the ongoing efforts to improve the welfare and conservation of leopards in captivity and to provide them with environments that support their natural behaviours, physical health, and psychological well-being.

## Material and methods

A total of four individually housed common leopards were observed during the study (Fig 1). All the leopards housed at NZP were fed buffalo calf meat once a day at around 5 pm in their feeding cubicles or night cells (except Fridays) during the study period. There are two enclosures for common leopards at NZP having an area of 183.12 m<sup>2</sup> and 175.01 m<sup>2</sup> (Fig 2). The enclosure is chain link mesh type with a stand-off barrier of more than 2 meters of height and a 30% viewing area for visitors.



**Figure 1.** Common leopard at National Zoological Park, New Delhi A: Tejas (Male), Wild birth, DOB-14.09.2012, Local ID-220006/Delhi; B: Bunty (Male), Wild birth, DOB-18.10.2019, Local ID-220008/Delhi; C: Bunty (Female), Wild birth, DOB- 01.04.2017, Local ID-220009/Delhi; D: Bubli (Female), Wild birth, DOB-15.10.2010, Local ID-220007/Delhi



**Figure 2.** Enclosure for common leopard at National Zoological Park, New Delhi

### Pre-enrichment Phase

In the first phase of the study, the behaviour assessments of four leopards were conducted using scan and focal sampling techniques (Altmann, 1974) and ethograms were developed (Stanton et al., 2015) to define and categorize specific behaviours of interest (Ethogram: Supplementary material). The behavioural assessments were conducted and the behaviour recorded was categorized into states and events according to the ethograms developed (see supplementary information). The effect of enrichment absence was taken into account i.e. pre-enrichment phase. During the pre-enrichment phase, the enclosure of leopards were having only an elevated space in one corner of the enclosure. Also, the one leopard was released at a time in the paddock area i.e. no social enrichment was employed. All the individual animals were studied when they were in the outdoor enclosure i.e. in the paddock or display area. Accordingly, the various behaviours exhibited by each individual under study were recorded in a pre-designed activity sheet.

### Post enrichment Phase

In the second phase, the assessment of the four leopards' behaviour was done for the effectiveness of enrichment activities (environmental enrichment provided along with social enrichment). The enrichment used comprises placing elevated wooden platforms, placing larger tree logs, hanging hessian bags at appropriate heights, hiding feed, and social enrichment (releasing a pair in the

paddock). The recorded activity was documented in a pre-designed activity sheet for analysis as done in the case of pre-enrichment data.

### **Data analysis**

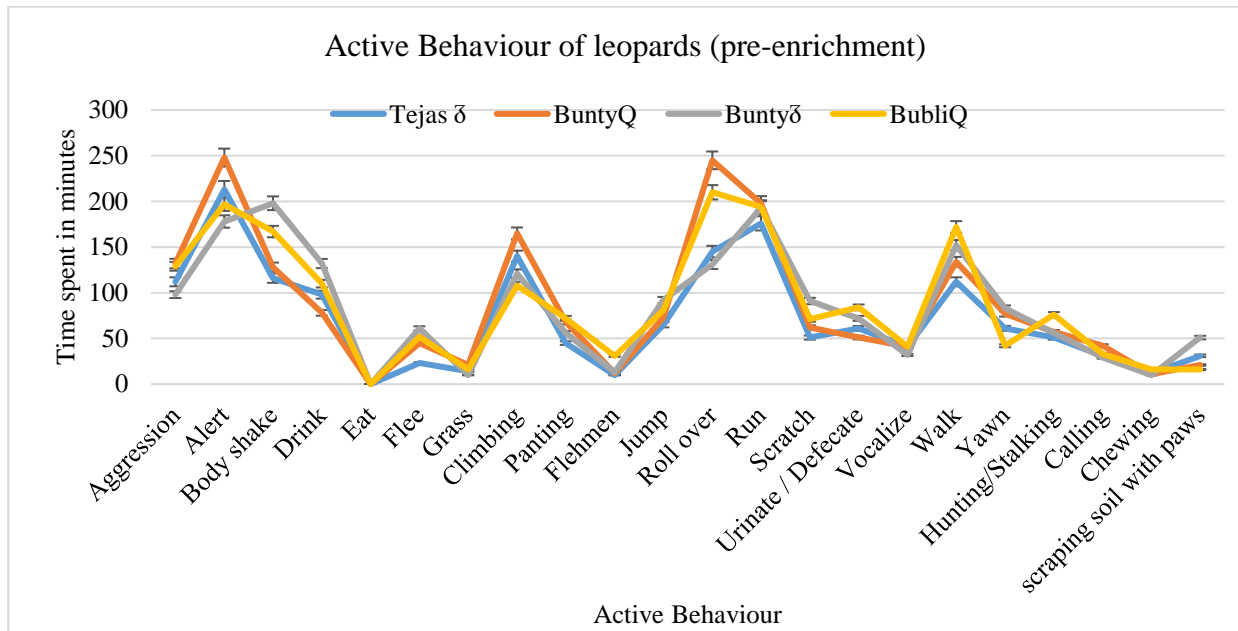
The data obtained/recorded was compiled in a Microsoft Excel Sheet (version 2010) daily. The ethogram was constructed by providing the time spent (in percentage) in performing each behavioural activity. For each individual, the percentage of active, inactive, and stereotypic behaviours was calculated. The first step in the data analysis process is to calculate the total frequency of each behaviour for each condition. This involves summing up the frequencies of each behaviour observed in the presence of enrichment, and absence of enrichment. The frequency count is performed separately for each leopard and behaviour category. The independent variable is enrichment, while animal activity (behaviour) was taken as the dependent variable. To determine whether the behaviour was influenced by the enrichment absence and presence, a Pearson correlation coefficient was subsequently conducted for each behavioural category for the species. This technique investigates the connection that occurs between a dependent variable and independent variables. Statistical tests such as ANOVA were also used to analyze the behaviour data and determine the significance of the observed changes.

### **Results**

The study includes four leopards housed at the NZP namely- Tejas, Bunty (male), Bunty (female), and Bubli. The behaviours exhibited by leopards during pre and post-enrichment phases are categorized into different types such as active, inactive, and stereotypic behaviours (supplementary information). The mean percentage of time spent (standard deviation) calculated for the different behaviours is mentioned in supplementary information.

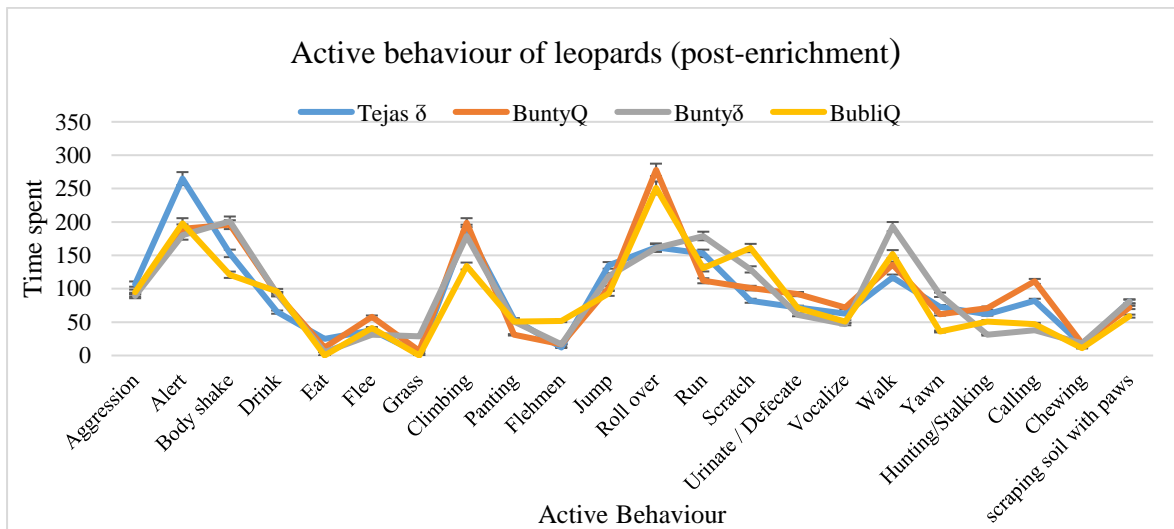
#### **Active behaviour during the pre-enrichment phase and post-enrichment phase**

The mean percentage of time spent (standard deviation) for the different active behaviour during the pre-enrichment phase by individual leopards is shown in Fig 3.



**Figure 3.** Active behaviour of leopards during the Pre-enrichment Phase

The mean percentage of time spent (standard deviation) for the different active behaviours during the post-enrichment phase by individual leopards is shown in Fig 4.



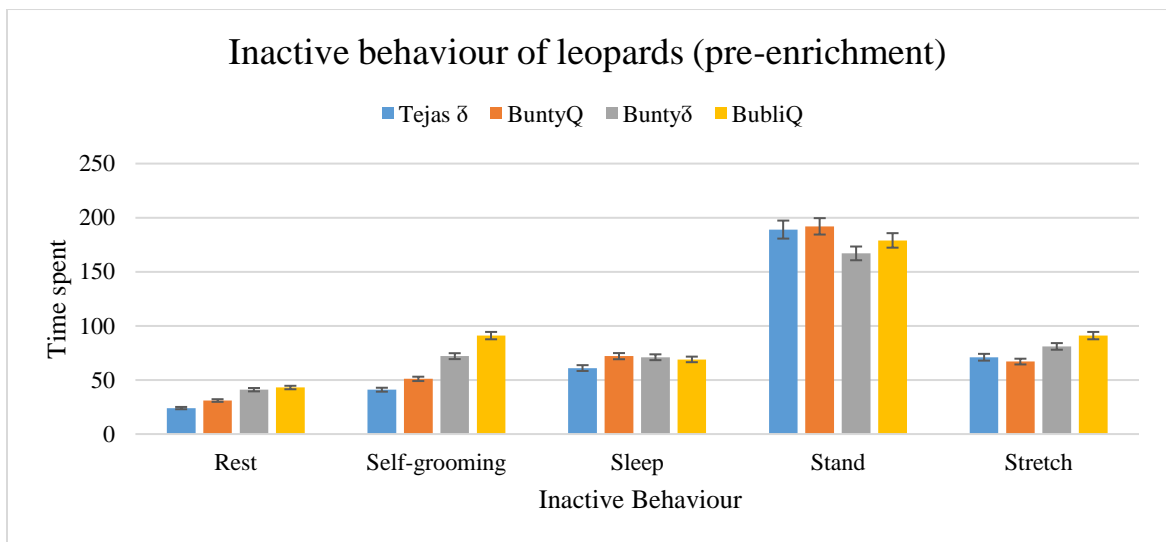
**Figure 4.** Active behaviour of leopards during the Post-enrichment Phase

Furthermore, a Pearson correlation coefficient (R) was computed to determine the direction and strength of a linear relationship between the dependent and independent variables. The results indicate an R-value of 0.486 in the case of active behaviour during the pre-enrichment period.

To assess a model's goodness of fit, the  $R^2$  value is also computed. This number indicates the proportion of the dependent variable's overall variation that can be accounted for by the independent variable. The adjusted  $R^2$  value is 0.238, while the  $R^2$  value is 0.241. Additionally, an ANOVA test was performed, and the findings indicate that the significance value is 0.247 and the F-statistic value is 2.107. The findings indicate an R-value of 0.352, an  $R^2$  value of 0.182, and an adjusted  $R^2$  value of 0.177 for the active behaviour during the post-enrichment phase. An F-statistic of 1.215 and a significance value of 0.371 are displayed by the ANOVA test.

### Inactive behaviour during the pre-enrichment phase and post-enrichment phase

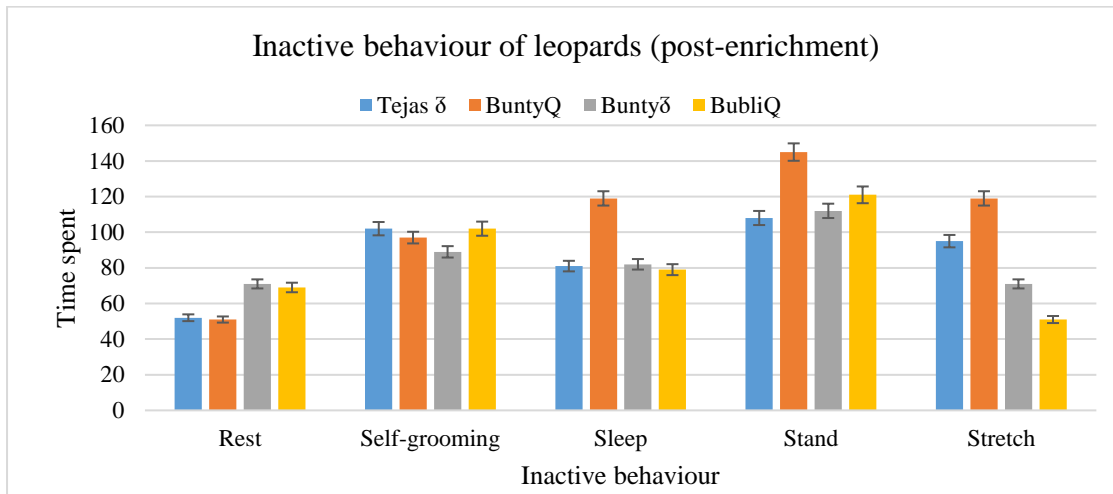
The mean percentage of time spent (standard deviation) for the different inactive behaviours during the pre-enrichment phase by individual leopards is shown in Fig 5.



**Figure 5.** Inactive behaviour of leopards during the Pre-enrichment Phase

The mean percentage of time spent (standard deviation) for the different inactive behaviour during the post-enrichment phase by individual leopards is shown in Fig 6.



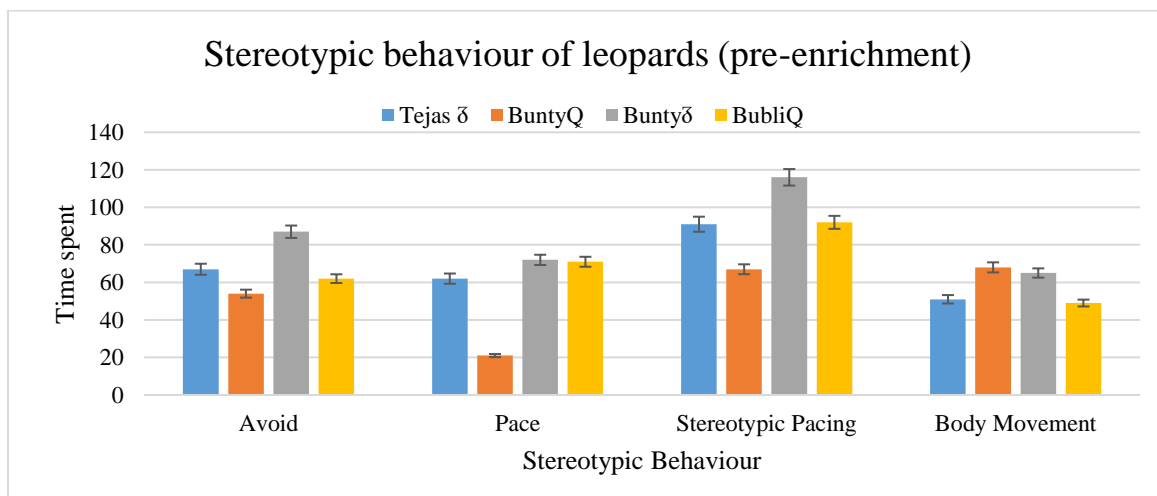


**Figure 6.** Inactive behaviour of leopards during the Post-enrichment Phase

The findings indicate an R-value of 0.377, an R<sup>2</sup> value of 0.141, and an adjusted R<sup>2</sup> value of 0.138 in the case of passive behaviour during the pre-enrichment period. An F-statistic of 2.741 and a significance value of 0.439 are displayed by the ANOVA test. The results indicate an R-value of 0.396, an R<sup>2</sup> value of 0.252, and an adjusted R<sup>2</sup> value of 0.247 in the event of inactive behaviour during the post-enrichment phase. An F-statistic of 1.436 and a significance value of 0.871 are displayed by the ANOVA test for post enrichment phase.

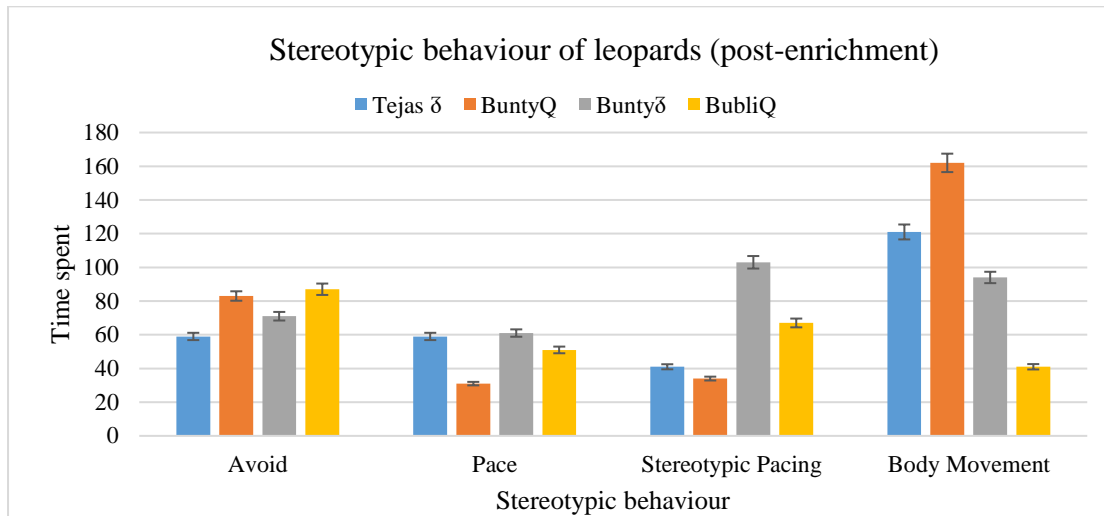
**Stereotypic behaviour during the pre-enrichment phase and post-enrichment phase**

The mean percentage of time spent (standard deviation) for the different stereotypic behaviours during the pre-enrichment phase by individual leopards is shown in Fig 7.



**Figure 7.** Stereotypic behaviour of leopards during the Pre-enrichment Phase

The mean percentage of time spent (standard deviation) for the different stereotypic behaviours during the post-enrichment phase by individual leopards is shown in Fig 8.



**Figure 8.** Stereotypic behaviour of leopards during the Post-enrichment Phase

The results indicate an R-value of 0.165, an  $R^2$  value of 0.214, and an adjusted  $R^2$  value of 0.211 in the case of stereotypical behaviour during the pre-enrichment phase. An F-statistic of 1.231 and a significance value of 0.786 are displayed by the ANOVA test. Additionally, the results for stereotypic behaviour during the post-enrichment phase display an R-value of 0.385, an  $R^2$  value of 0.417, and an adjusted  $R^2$  value of 0.413. An F-statistic of 2.182 and a significance value of 0.892 are displayed by the ANOVA test during the post-enrichment phase.

## Discussion

### Active behaviour of common leopard during pre and post-enrichment phases

Leopards displayed a range of active behaviours both during pre and post-enrichment. During the pre-enrichment phase, Tejas, a leopard, exhibited active alert behaviour compared to other behaviours. Tejas's mean duration of alert behaviour was  $213 \pm 9.4$ . Tejas had active behaviour alertness for a considerable amount of time throughout the post-enrichment period; on average, Tejas spent an average time of  $265 \pm 9.71$ . It demonstrates that Tejas engaged in active behaviour alertness for a longer period than other active behaviours during both the pre-and post-enrichment phases. Compared to the pre-enrichment phase, Tejas spent more time during the post-enrichment phase being alert to active behaviour.

During the pre-enrichment period, the male leopard named Bunty showed more active alert behaviour than other behaviours; on average, Bunty spent an average time of  $248 \pm 9.79$  engaging

in alert behaviour. Bunty, a male, engaged in active behaviour during the post-enrichment phase, climbing for an extended period (mean time spent:  $199 \pm 6.72$ ). It shows that Bunty, a male, engaged in active behaviour alertness for a considerable amount of time during the pre-enrichment period before switching to climbing during the post-enrichment phase. Bunty, a male, spent more time during the pre-enrichment phase being alert and active behaviour than he did during the post-enrichment phase when it came to active behaviour climbing. Compared to other active behaviours, a female leopard named Bunty showed body shaking as an active behaviour for a considerable amount of time during both the pre-and post-enrichment phases.  $198 \pm 7.52$  average time was spent on body shaking behaviour during pre-enrichment, and  $201 \pm 7.24$  average time was spent on it during post-enrichment. Bunty (a female) spent more time on average engaging in active behaviour during post-enrichment than she did during pre-enrichment. During the pre-enrichment phase, rolling was the active behaviour displayed by a leopard named Bubli for a longer period than other behaviours; on average, Bubli rolled for an average time of  $210 \pm 7.87$ . It was modified to the alerting phase during the post-enrichment phase.

The current study's findings showed that enrichment improved the active behaviour of captive leopards, which is consistent with findings made by Panchal et al. (2021) who observed that the active behaviour of captive leopards was influenced by the use of different active and passive enrichment regimes, as determined by examining the levels of glucocorticoid metabolites in the leopards' faecal samples.

### **Inactive behaviour of common leopard during pre and post-enrichment phases**

Throughout the study period, the four leopards displayed a range of inactive behaviours. During the pre-enrichment phase, Tejas, a leopard, stood for an average time of  $189 \pm 8.34$ , and during the post-enrichment phase, Tejas stood for an average time of  $108 \pm 3.96$ . In contrast to other inactive behaviours, this demonstrates that Tejas engaged in inactive behaviour standing for extended periods throughout both the pre-and post-enrichment phases. Tejas, however, demonstrated standing behaviour for a longer period during the pre-enrichment phase than the post-enrichment phase, as evidenced by the fact that the amount of time spent standing was higher during the pre-enrichment phase.

In comparison to other inactive behaviours, a male leopard named Bunty spent an average time of  $192 \pm 7.58$  standing in the pre-enrichment phase and  $145 \pm 4.89$  average time standing in the post-enrichment phase. This indicates that Bunty (male) performed inactive behaviour standing for a longer period in both pre and post-enrichment phases; however, the amount of time spent standing

in the pre-enrichment phase was greater than in the post-enrichment phase, indicating that Bunty (male) stood for a longer period in the pre-enrichment phase than in the post-enrichment phase.

The average amount of time that a female leopard named Bunty spent standing in the pre-enrichment phase was  $167 \pm 6.34$ , and the average amount of time Bunty (female) spent standing in the post-enrichment phase was  $112 \pm 4.03$ . This indicates that, in comparison to other inactive behaviours, Bunty (the female) performed inactive behaviour standing for a longer period in both the pre-and post-enrichment phases. However, the amount of time Bunty (female) spent standing in the pre-enrichment phase was greater than the amount of time she spent doing so in the post-enrichment phase.

The data indicates that a leopard named Bubli engaged in inactive behaviour standing for an average time of  $179 \pm 6.71$  during the pre-enrichment phase and  $121 \pm 4.7$  average time during the post-enrichment phase. This indicates that Bubli engaged in inactive behaviour standing for longer periods during both pre and post-enrichment phases than other inactive behaviours, but that the amount of time spent standing during pre-enrichment was greater than during post-enrichment, indicating that Bubli stood for a longer period during the pre-enrichment phase than in post-enrichment phase. The current study's findings show that using various enrichments for leopards has reduced their inactive behaviour. Decker et al. (2023) have also recommended the use of enrichment for the welfare of animals housed in captivity.

### **Stereotypic behaviour of common leopard during pre and post-enrichment phases**

Throughout the pre- and post-enrichment phases, the four leopards showed a range of stereotypical behaviours. Tejas engaged in stereotypical behaviour, such as stereotypical pacing, for an average time of  $91 \pm 4.01$  during the pre-enrichment phase and an average time of  $121 \pm 4.43$  during the post-enrichment phase, which involved body movement. This demonstrates that, in contrast to other stereotypical behaviours, Tejas the leopard engaged in stereotypical behaviour such as stereotypical pacing for an extended period during the pre-enrichment phase and stereotypical behaviour such as body movement for an extended period during the post-enrichment phase. Pre-enrichment was associated with a higher amount of time spent on stereotypical pacing behaviour than post-enrichment, while post-enrichment was associated with a higher amount of time spent on body movement behaviour than pre-enrichment.

When compared to other inactive behaviours, the male leopard Bunty spent an average time of  $68 \pm 2.68$  and  $162 \pm 5.47$  engaging in stereotypic behaviour, or body movement, during the pre-and post-enrichment phases, respectively. This indicates that Bunty engaged in stereotypic behaviour,

or body movement, for a longer period during both pre and post-enrichment conditions. However, the amount of time spent on body movement behaviour during the post-enrichment phase was greater than during the pre-enrichment phase. This demonstrates that the male leopard bunty moves their body more during the post-enrichment period than during the pre-enrichment period. The findings indicate that stereotypic behaviour, or stereotypical pacing, occurred at on average time of  $116 \pm 4.4$  during the pre-enrichment phase in the case of a female leopard named Bunty and an average time of  $103 \pm 3.71$  during the post-enrichment phase. This indicates that Bunty, a female, engaged in stereotypical behaviour, such as stereotypic pacing, for a longer period during the pre- and post-enrichment conditions than Bunty did for other inactive behaviours. However, Bunty spent a greater amount of time engaging in this behaviour during the post-enrichment phase than during the pre-enrichment phase.

The average amount of time spent on stereotypic behaviour, such as stereotypical pacing during the pre-enrichment phase, was  $92 \pm 3.45$  in the instance of the leopard named Bubli, while the average amount of time spent on avoidance during the post-enrichment condition was  $87 \pm 3.38$ . This demonstrates that, in comparison to other stereotypical behaviours, Bubli engaged in stereotypical pacing during the pre-enrichment condition and avoided stereotypical behaviour for a considerable amount of time during the post-enrichment condition. Pre-enrichment was associated with a higher amount of time spent on stereotypical pacing behaviour than post-enrichment, and post-enrichment was associated with a higher amount of time spent on avoidance behaviour. Mallapur & Chellam (2002) have observed that Indian leopards pace more stereotypically. Additionally, studies on lion-tailed macaques kept in captivity have shown higher levels of stereotypical pacing (Mallapur et al., 2005). The current study confirms what other researchers have shown, which is that enrichment lessens the stereotypical behaviour of leopards. Environmental enrichment has been proposed by Shyne (2006); and Swaisgood & Shepherdson (2006) as a means of mitigating stereotyping in caged animals while zoo visitors are present.

Vaz et al. (2017) also investigated stereotypic behaviour and stress physiology in a subpopulation of two big felid species housed in six Indian zoos using conventional behaviour scoring, non-invasive stress monitoring, and contextual factors. Observations of tiger behaviour revealed that throughout the day, tigers spent more time stereotyping (12%) than leopards (7%) did. Stereotypic behaviour increased significantly with faecal corticosterone metabolites (FCM) levels in tigers and leopards when health state and tree cover, stone, den, and keeper attitude were controlled. Stereotypic prevalence decreased with larger enclosures, enclosure enrichments like the presence

of pools and stones when managed socially with conspecifics, and when the keeper had a positive attitude, according to a comparison of tiger stereotypes with various biological and environmental factors using binary logistic regression. These factors accounted for 43% of variations in tiger stereotype prevalence. Similarly, the results of the present study also show that with the presence of enrichment in an animal enclosure, the behaviour of animals changes, and stereotypic behaviour is reduced. Besides, Juhari (2015) showed that the stereotypic pacing response of captive leopards (*Panthera pardus linnaeus*) in Malaysian zoos is affected by feeding and olfactory enrichment practices.

During the present study, the effects of enrichment on leopards are examined for active, inactive, and stereotypical behaviour in two scenarios: pre- and post-enrichment phases. The results of the study showed that the impact of different types of enrichment is favourable. By monitoring the leopard's positive active behaviour during both the pre- and post-enrichment phases, it may be inferred that this behaviour was not statistically significant. Regarding the leopard's inactive behaviour, the pre-enrichment phase observed a negative effect and the post-enrichment phase noticed a positive effect, but these effects were not statistically significant. Finally, it is determined that there is an influence of enrichment on the individual leopards, although it is not statistically significant, in both pre and post-enrichment phases for active, passive, and stereotypical behaviour. Ward et al. (2024) also studied the relation between enrichment and animal age and suggested age-specific enrichment to be used for the welfare of zoo-housed carnivores. The findings of the present study are partially in line with other researchers, who have suggested that these behavioural changes are linked to enrichment. However, the behaviour is observed to be individual animal specific (maybe age specific) about the enrichment use. The present study suggests the need for future research into individual-specific (age-specific) different types of enrichment for captive felids.

## **Conclusion**

This study investigated the effect of enrichment on the active, inactive, and stereotypic behaviour of four leopards housed at the National Zoological Park, New Delhi. The study revealed that the absence of enrichment can result in stress, disturbances, and altered behavioural patterns, including developing stereotypic behaviours among leopards. The present study involves individual animal-specific behaviour, which is important for zoos, as it could be helpful to formulate individual animal-specific environmental enrichment plans and make well-versed husbandry guidelines and animal enclosure designs that may meet all the animals' behavioural requirements. Indeed,

knowing the type and extent of behavioural changes due to the absence and presence of enrichment may help in planning specific environmental enrichment programs (e.g., olfactory cues enhancing exploration or marking) as well as improving enclosure design (e.g., hiding areas).

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## Supplementary information

### S1. Ethograms for different behaviours shown by common leopards during the study

Behaviour Type	Behaviour	Definition
Active behaviour	Aggression	Attacking, chasing, biting, growling, fight (Stanton et al., 2015)
	Alertness	Observing the environment by watching carefully, sniffing the air, and listening to something (ears moving) (Spiezio et al., 2023)
	Body Shake	Rotates its abdomen from side to side. (Stanton et al., 2015)
	Drinking	Ingests water (or other liquids) by lapping up with the tongue (Stanton et al., 2015)
	Eating	Ingests food (or other edible substances) using chewing with the teeth and swallowing (Stanton et al., 2015)
	Fleeing	runs away from (modifier) (Stanton et al., 2015)
	Grass Activities	Eating grass for digestion/Maintenance (Spiezio et al., 2023)
	Climbing	Ascends and/or descends an object or structure (Stanton et al., 2015)
	Panting	To breathe quickly
	Flehmen Response	Makes a grimaced facial expression, where the mouth is open, upper lip is elevated, and tongue may protrude out of the mouth (Stanton et al., 2015)
	Jumping	Leaps from one point to another, either vertically or horizontally (Stanton et al., 2015)
	Rolling Over	While lying on the ground, cat rotates body from one side to another. During the roll, the back is rubbed against ground, the belly is exposed and all paws are in the air. Animal may continue rolling repeatedly from side to side (Stanton et al., 2015).
	Running	Forward locomotion in a rapid gait, which is faster than walking or trotting (Stanton et al., 2015).
	Scratching	Scratches its body using the claws of its hind feet (Stanton et al., 2015).
	Urination/Defecation	Releases urine on the ground while in a squatting position/ Releases feces on the ground while in a squatting position. (Stanton et al., 2015).
	Vocalizing	Produces sounds or calls, originating from the throat and mouth (Stanton et al., 2015).
	Walking	Forward locomotion at a slow gait (Stanton et al., 2015).
	Yawning	Opens its mouth widely while inhaling, then closes mouth while exhaling deeply (Stanton et al., 2015).
	Hunting/Stalking	Actively pursues live prey. Includes movements such as crouching, stalking, or any other species-specific behavior (Stanton et al., 2015).
Calling	Produces sounds or calls, originating from the throat and mouth (Stanton et al., 2015).	

	Chewing	Grinds an object in its mouth using the teeth (Stanton et al., 2015).
	Scraping Soil With Paws	Cleaning nearby areas with paws by scraping the soil of the enclosure
<b>Inactive behaviour</b>	Rest	Not showing any activity
	Self-Grooming	Cleans itself by licking, scratching, biting or chewing the fur on its body. May also include the licking of a front paw and wiping it over one's head (Stanton et al., 2015).
	Sleep	Lying on the ground with its head down and eyes closed, performing minimal head or leg movement, and is not easily disturbed (Stanton et al., 2015).
	Standing	Is in an upright position and immobile, with all four paws on the ground and legs extended, supporting the body (Stanton et al., 2015).
	Stretching	Extends its forelegs while curving its back inwards (Stanton et al., 2015).
<b>Stereotypic behaviour</b>	Avoidance	Moves, or changes direction while moving, in order to keep away from (modifier) (Stanton et al., 2015).
	Pacing	Moving here and there regularly. Abnormal behaviour (Spiezio et al., 2023)
	Stereotypic Pacing	Abnormal behaviour (Spiezio et al., 2023)
	Body Movement	Locomotion-moving around in the enclosure by walking, climbing, jumping etc continuously (Spiezio et al., 2023)

## S2. Active behaviour of common leopards during pre-enrichment phase (Mean and standard deviation)

Leopard	Aggression	Alert	Body shake	Drink	Eat	Flee	Grass	Climbing	Panting	Flehmen	Jump	Roll over	Run	Scratch	Urinate / Defecate	Vocalize	Walk	Yawn	Hunting/Stalking	Calling	Chewing	scraping soil with paws
<b>Tejas</b>	112 ±4.94	213 ±9.4	116± 5.12	98± 4.32	0 0	23± 1.0	14± 0.6	140 ±6.1	45± 1.9	10± 0.44	65± 2.8	145 ±6.4	176 ±7.7	51±2. 25	61±2.6 9	41± 1.8	112 ±4.9	61±2 .69	51±2.2 5	31± 1.3	12± 0.52	31± 1.3
<b>Bunty (male)</b>	132 ±5.21	248 ±9.79	128± 5.05	78± 3.08	0 0	45± 1.7	21± 0.8	165 ±6.5	68± 2.6	12± 0.47	73± 2.8	245 ±9.6	198 ±7.8	62±2. 44	51±2.0 1	41± 1.6	134 ±5.2	77±3 .04	57±2.2 5	42± 1.6	11± 0.43	21± 0.8
<b>Bunty (female)</b>	98± 3.7	178 ±6.7	198± 7.52	132 ±5.0	0 0	61± 2.3	10± 0.3	121 ±4.5	56± 2.1	13± 0.49	92± 3.4	131 ±4.9	193 ±7.3	91±3. 45	72±2.7 3	32± 1.2	152 ±5.7	83±3 .15	56±2.1 2	29± 1.1	10± 0.38	51± 1.9
<b>Bubli</b>	129 ±4.84	197 ±7.3	167± 6.26	110 ±4.1	0 0	52± 1.9	16± 0.6	108 ±4.0	72± 2.7	31± 1.16	81± 3.0	210 ±7.8	194 ±7.2	71±2. 66	84±3.1 5	41± 1.5	172 ±6.4	42±1 .57	76±2.8 5	33± 1.2	16± 0.6	16± 0.6

## S3. Inactive behaviour of common leopards during pre-enrichment phase (Mean and standard deviation)

Leopards	Rest	Self-grooming	Sleep	Stand	Stretch
<b>Teja's</b>	24±1.05	41±1.81	61±2.69	189±8.34	71±3.13
<b>Bunty male</b>	31±1.22	51±2.01	72±2.84	192±7.58	67±2.64
<b>Bunty female</b>	41±1.55	72±2.73	71±2.69	167±6.34	81±3.07
<b>Bubli</b>	43±1.61	91±3.41	69±2.58	179±6.71	91±3.41

## S4. Stereotypic behaviour of common leopard during pre-enrichment phase (Mean and standard deviation)

Leopards	Avoid	Pace	Stereotypic Pacing	Body Movement
<b>Tejas's</b>	67±2.95	62±2.73	91±4.01	51±2.25
<b>Bunty male</b>	54±2.13	21±0.82	67±2.64	68±2.68

<b>Bunty female</b>	87±3.3	72±2.73	116±4.4	65±2.47
<b>Bubli</b>	62±2.32	71±2.66	92±3.45	49±1.83

**S5. Active behaviour of common leopards during the post-enrichment phase (Mean and standard deviation)**

leopard	Aggression	Alert	Body shake	Drink	Eat	Flee	Grass	Climbing	Panting	Flehmen	Jump	Roll over	Run	Scratch	Urinate / Defecate	Vocalize	Walk	Yawn	Hunting/Stalking	Calling	Chewing	swabed up/pos samples
<b>Teja's</b>	107±3.92	265±9.71	153±5.61	65±2.38	25±0.91	38±1.39	3±0.11	189±6.93	54±1.98	12±0.44	135±4.95	162±5.94	153±5.61	82±3	72±2.64	63±2.31	117±4.29	73±2.67	62±2.27	82±3	16±0.58	81±2.97
<b>Bunty male</b>	91±3.07	190±6.41	196±6.62	92±3.1	12±0.06	58±1.95	7±0.23	199±6.72	31±1.04	17±0.57	101±3.41	278±9.39	112±3.78	101±3.41	92±3.1	72±2.43	136±4.59	62±2.09	71±2.39	111±3.75	18±0.6	72±2.43
<b>Bunty female</b>	89±3.2	180±6.48	201±7.24	92±3.31	5±0.18	31±1.11	29±1.04	179±6.44	51±1.83	17±0.61	119±4.28	161±5.79	179±6.44	129±4.64	61±2.19	47±1.69	193±6.95	91±3.27	31±1.11	38±1.36	18±0.64	81±2.91
<b>bublie</b>	95±3.69	198±7.7	121±4.7	96±3.73	00	41±1.59	00	134±5.21	51±1.98	52±2.02	93±3.61	251±9.76	131±5.09	161±6.26	71±2.76	51±1.98	152±5.91	36±1.4	51±1.98	47±1.82	11±0.42	59±2.29

**S6. Inactive behaviour of common leopards during the post-enrichment phase (Mean and standard deviation)**

<b>Leopards</b>	<b>Rest</b>	<b>Self-grooming</b>	<b>Sleep</b>	<b>Stand</b>	<b>Stretch</b>
<b>Teja's</b>	52±1.9	102±3.74	81±2.97	108±3.96	95±3.48
<b>Bunty male</b>	51±1.72	97±3.27	119±4.02	145±4.89	119±4.02
<b>Bunty female</b>	71±2.55	89±3.2	82±2.95	112±4.03	71±2.55
<b>Bubli</b>	69±2.68	102±3.96	79±3.07	121±4.7	51±1.98

**S7. Stereotypic behaviour of common leopards during the post-enrichment phase (Mean and standard deviation)**

<b>Leopards</b>	<b>Avoid</b>	<b>Pace</b>	<b>Stereotypic Pacing</b>	<b>Body Movement</b>
<b>Tejas's</b>	59±2.16	59±2.16	41±1.5	121±4.43
<b>Bunty male</b>	83±2.8	31±1.04	34±1.14	162±5.47
<b>Bunty female</b>	71±2.55	61±2.19	103±3.71	94±3.38
<b>Bubli</b>	87±3.38	51±1.98	67±2.6	41±1.59