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Study on Diurnal Activity Pattern of Captive Leopard (*Panthera pardus*) in Alipore Zoological Garden, Kolkata, India

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Abstract: Wild carnivorous animals are difficult to be housed in captivity due to their wide home range and specific diet. As captive animal's behavioural data are used as a welfare indicator, diurnal behavioural study and time budgeting of a male leopard (*Panthera pardus*) was carried out from 10:00 h to 17:00 h from June 2022 to May 2024 in Alipore Zoological Garden, Kolkata, India by using focal sampling method for 33,600 min. During observation period, the study identified 15 active behaviours, 9 passive behaviours, 4 other, and 1 stereotypic behaviour, pacing. The leopard showed significant variations in behavioural activities among different seasons and in different diurnal hours. During monsoon season, the leopard spent most of its time sleeping (26.23±0.47%) whereas, pacing (26.05±0.48%) during winter season and sitting (23.31±0.37%) during summer season. During all the seasons, active behaviours like feeding of offered feed was recorded with highest value followed by walking. Again, among the passive behaviours the leopard allocated most of its time sleeping during monsoon while, sitting during summer. When different diurnal hours were compared, walking was found to reach the peak in the first hour of observation during monsoon (5.83%) and summer (8.88%) whereas, during winter in the 1st, 3rd and 6th hours of observation (5.27-5.69%). The leopard allocated majority of its time sleeping (50.83%) during 4th hour of observation in monsoon and sitting (32.22%) during 3rd hour of observation in summer. During winter season, the leopard was mostly engaged in stereotypic pacing (51.94%) in 1st hour of observation. The incidence of higher stereotypic activity suggests the need of further studies for enlightening the cause of this abnormal behaviour and whether there is any need for adopting conservation strategies for their well-being in captivity.

Keywords: Alipore Zoological Garden, Diurnal behavioural study, Focal sampling, *Panthera pardus*, Time budgeting, Captivity, Stereotypic behaviors, Yawning, Urine spraying, Defecation, Grooming, Ethogram

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Introduction

The study of animal behaviour scrutinizes into the elaborate ways through which animals interact with each other, their environment and other life forms. It undertakes their interactions with

surroundings and other organisms, covering topics such as intrinsic stimuli which includes craving, anxiety etc., and extrinsic stimuli which includes resources, competitors, environmental factors and habitat availability (Gaulin, 1979; Zielenski *et al*., 1983). These behavioural studies serve as a crucial method for determining the welfare of animals in zoos by investigating abnormal and stereotypic behaviours, as well as prepare a comparison scenario of behaviours with those exhibited by conspecifics in the wild (Robinson 1998). The documentation of stress and welfare through behavioural study of captive animal requires a sound knowledge of normal species-specific behaviour and variances in response to various stimuli and emotions (Keeling and Jensen, 2002; Squires, 2003). In this aspect, behavioural studies proved to be vital for conservation of wild animal in captivity (Sutherland and Gosling, 2000).

Zoos play a significant role in *ex situ* conservation of wild animals. Approximately 26 billion animals are kept in captivity all over the world (Mason, 2010). For a notable period, enclosures are one of the most important components of zoo animal collections and leopard is one of them. One of the five extant species in the *Panthera* genus is the leopard (*Panthera pardus*) which is recognized by its slender and muscular body, possessing relatively short limbs and a broad head. Sexual dimorphism is also exhibited by them, with males being larger and heavier than females (Hoath, 2009). It is covered with a pale yellowish to dark golden fur, embellished by dark spots grouped in rosettes. The leopard roams its domain alone, justifying its solitary nature and territorial behavior. Leopards spend the majority of their day resting in thickets, among rocks, or perched over tree branches as they are active from dusk till dawn. They prosper primarily in savannas, rainforests, and areas where grasslands, woodlands, and riverine forests remain undisturbed, (Nowell and Jackson, 1996). They reside in marginal habitats in sub-Saharan Africa. They are distributed widely across Africa, the Caucasus, and Asia, although their populations are fragmented and declining. Diminishing natural prey base, elevating conflicts with livestock herders, and high mortality rates among leopards, are all consequences of habitat fragmentation and conversion of forests to agricultural lands. Along with that, trophy hunting and poaching cause considerable threats (Stein *et al*., 2023). For this reason, leopard is considered as vulnerable by the IUCN (www.iucnredlist.org, 2015). Conservation efforts are immediately required to mitigate the problem caused due to shrinking population of leopards.

Zoos are one of the means to carry out not only wildlife conservation but also provide education and public awareness. Thus, zoos are required to maintain the certainty of both physical and mental well-being of captive animals to support their conspecifics in the wild. The wild animals do not thrive well in captivity due to chronic stress as captive conditions are vastly different from wild environments. Factors such as noise, vicinity and visitor size have an impact on captive animals' responses, with the occurrence of stereotypic behaviors which are often observed in response to large and noisy human audiences (Mallapur and Chellam, 2002). Stereotypy is regarded as an irregular behavior that indicates poor psychological well-being of captive animals (Boorer, 1972; Mason, 1991; Marriner and Drickamer, 1994). To elaborately identify the welfare of captive populations, more researches on these behaviours in comparison to wild counterparts are vividly required (Keeling and Jensen, 2002). Visitors at zoological parks often interact with captive animals, which leads to considerable changes in their behavioral patterns (Davey 2007; Cole and Fraser, 2018). The occurrence of stereotypic behaviors exhibited by animals in captivity, suggests stress and anxiety induced by the captive environment (Lyons et al. 1997). Leopard is not an exception to this fact. They face a vast challenge due to their natural predatory hunting behaviors. In zoos, they are housed in closed enclosures. Confinement in smaller areas can affect their behaviors in spite of being highly flexible and adaptable carnivores

(Henschel *et al*., 2008). Stereotypic pacing (Davey, 2007; Mason *et al*., 2007), a repetitive and aimless locomotor behavior, observed in captive animals can be greatly induced by public exposure (Mason *et al*., 2007).

The aim of this study was to observe welfare and behavioural patterns of leopard throughout the monsoon, winter and summer season, in an outdoor *ex situ* conservation enclosure. Recent researches about animal welfare in captive environment, concentrating on how different zoo animals adapted in different captive environments, and on the identifying of different stereotypic behaviours with their intensity rate, and ultimately reporting the need of various welfare strategies. Several ecological studies and research about the behavioural pattern of *Panthera pardus* in captivity have been conducted throughout the world (Mallapur and Chellam 2002; Apelqvist, 2014; Sethy and Mohapatra, 2020; Gupta *et al*., 2022). There is a need of detailed diurnal activity budgets for zoo leopards for ensuring their welfare in captivity and conservation efforts. Hence, the present study aimed to establish an intricate diurnal activity time budget for a male leopard housed at Alipore Zoological Garden in Kolkata, India over a period of one year. Various behavioral patterns, including, feeding of offered feed, drinking, eating grasses, sitting, walking, panting and other diurnal activities, were observed. The objective was to develop an ethogram for a male leopard named 'Sisir' and to assess the seasonal variations in behaviors throughout the study period.

Materials and Methods

Study site

The current study on the behavioral patterns of the leopard was conducted at Alipore Zoological Garden (22◦32'9.29''N, 88◦19'55.39"E) in Kolkata,West Bengal, India. It was established on 1st January 1876 and is one of India's oldest zoological parks and a prominent tourist destination, covering an area of approximately 18.811 hectares. The zoo houses a diverse range of animals from nearly all vertebrate groups, totaling around 1300 individuals. Notably, the zoo serves as an ecological haven for numerous winter migratory birds. The area is featured with loamy alluvial soil and it experiences a moderate climate, with summers beginning in March and ending with the onset of the rainy season. Summer temperatures can peak at 42°C, with an average of 35°C. The winter season extends from the end of the rainy season until February, with temperatures dropping to the lowest 8°C and averaging around 13°C. Monsoon spans from July to September, contributing to an annual rainfall of approximately 1641.4 mm in Kolkata.

Studied animal

The study was conducted to observe the behaviour of a male leopard of around 5 years of old, named 'Sisir'. The study animal was bought from the 'Bengal Safari Park', Siliguri in July, 2019. The food offered to the leopard, basically includes buffalo meat which was about 4 kg per day except Thursday, fasting day. The food was provided once in a day at around 16:30 h inside the enclosure.

Enclosure of the animal

The animal is kept in an open-air enclosure (Fig. 1) which was about 689.66 sq.m. situated on the west side of Alipore Zoological Garden. Inside the enclosure, there were many trees and the floor of the enclosure was covered with grasses. The front side of the enclosure was guarded with a glass wall whereas the other three sides with the netted fence. A row of grass was present in front of the glass wall and netted fence. On the front side, just beyond the glass wall, there was a railing to keep the visitors away from the glass wall. Inside the enclosure, on its extreme end, there was a night shelter for the leopard. It was also found a water body inside the enclosure. There were one double layered and a triple layered stands where the leopard took rest for most of its diurnal hours.

Data collection

For the study on activity pattern of the male leopard, data were collected from monsoon to summer seasons (4 months from monsoon,

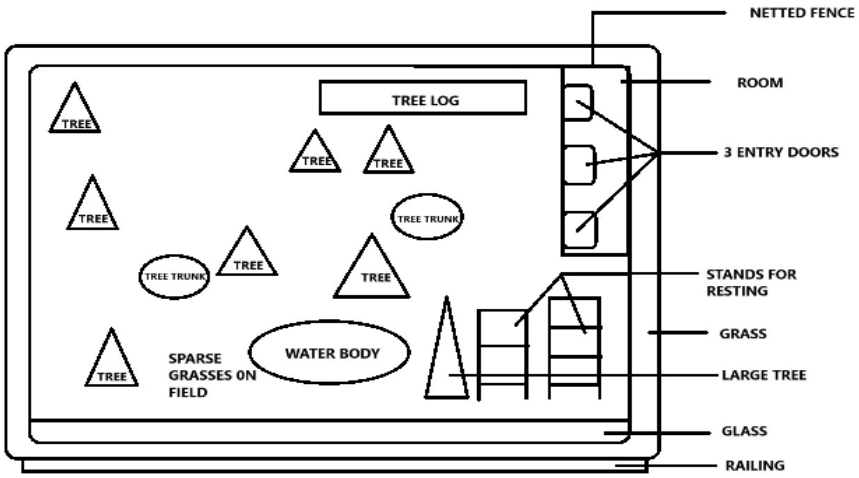

Fig. 1: Layout of Indian leopard enclosure at Alipore Zoological Garden (based on visual observations during present study).

4 months from winter and 4 months from summer). Simple observations were done to estimate the behavioural pattern displayed by the leopard using unaided eye. Focal sampling method was used (Altmann, 1974). The activities performed by the studied leopard were recorded and marked on a sheet between 10:00 h to 17:00 h twice in a week. All the activities were noted in each minute with a gap of 1 min in every 5 min from a suitable point from where the enclosure was best visible without creating any disturbances to the animal or environment. Total observation was carried out for 33,600 min.

Ethogram

An ethogram serves as a comprehensive list of typical behaviors performed by an animal, as a complete inventory of the behavior patterns of a species (Tinbergen, 1951). According to Marin and Bateson (1993), an animal's activity pattern naturally involves a continuous flow from one event or state to another, where an 'event' is a short behavior pattern or an 'activity' such as body movement or vocalization at a specific point of time. Frequency of repetition is a key feature of events, while a "state" refers to a prolonged activity like resting, sleeping, or standing, often characterized by its time duration (Martin and Bateson, 1993). Categorizing the behaviors with names and a proper description, allows the researchers to make distinctions and measurements of each activity displayed by the studied animal. Understanding the complexity of an animal's behavior and its function, requires familiarity and insights into its behavior. Analyzing diverse activities within a specified time period allows for comparisons between behaviors expressed by wild and captive leopards, aiming to identify differences and their causes. Additionally, budgeting combined with energy expenditure assessments provides valuable insights into species' energy expenditure (Deag, 1985; Chattopadhyay and Bhattacharya, 1986). A total of 29 activities were recorded for the leopard in Alipore Zoological Garden. Those activities were categorized into four major types including active, passive, others and stereotypic.

The identified activities under the type active behaviour were feeding of offered, eating grass, crouch, drinking, jumping, climbing, locomotion (walking, running), aggressive, territorial (scratching on object, urine spraying, defecation), exploration (alert, sniff, explore). Again, the identified passive behaviours were standing, resting (sitting, sitting erect, resting wake, sleeping), yawning, grooming (licking itself, rubbing, rolling over). Vocalization, panting, human interaction, animal interaction are under

Table 1: Ethogram used for collecting behavioural data of leopards, *Panthera pardus* in captivity at Alipore Zoological Garden, Kolkata (based on Mallapur and Chellam, 2002; Sethy and Mohapatra, 2020; Mallapur *et al.*, 2002; Ngoprasert *et al*., 2007)

Category	Type	Sub-type	Description
Active	Feeding of offered feed		Procuring nutrient by food, provided by the zoo staff.
	Eating grasses		Consuming grasses
	Crouch		Bending the body downward and forward by bending its legs and spine
	Drinking		Taking water either offered to it or from its surrounding environment
	Jumping		Moving from one surface to another when at one point all the four limbs remain in the air
	Climbing		Showing vertical locomotion when it moves up or down with the help of its four limbs
	Locomotion	Walking	Changing its position or moves from one place to another with the help of four limbs
		Running	Changing its position or moving from one place to another quickly with help of four limbs
	Aggressive		Running after another individual or object, sometimes uses claws and teeth to attack
	Territorial	Scratching on object	Showing repetitive up and down movement by quickly moving finger nails on any inanimate object of its territory
		Urine spraying	Marking objects on its territory by spraying urine
		Defecation	Marking its territory by defecating on specific spots of its territory
	Exploration	Alert	Observing an object carefully by fixing its gaze on the object
		Sniff	Performing a specialized respiratory behaviour for smelling an object by placing its nose close to the object
		Explore	Observing an object by moving head close towards the object, touching it with its paw
Passive	Standing		Standing with all its four legs perpendicular to the ground
	Resting	Sitting	Siting with its four legs stretched on ground or above another object along with its head always upright and eyes open
		Sitting erect	Period of inactivity ,siting with fore limbs straight as in standing manner with eyes open
		Resting awake	Period of inactivity without showing any maintenance behaviour, may sit or lay down with eyes closed
		Sleeping	A non-responsiveness state, laying down with its eyes closed
	Yawning		Along inspiratory phase with gradual mouth gaping
	Grooming	Licking itself	Maintaining self-hygiene by its own fur
		Rubbing	Rubbing its head or body on an inanimate object
		Rolling over	Rolling on ground by turning from one side to another on support of its back
Others	Vocalization		Producing an audible sound by the action of respiratory system
	Panting		Method of cooling by rapid inhalation of air through nasal cavity and exhalation through mouth
	Human interaction		Showing any manner of behaviour or interacts with people
	Animal interaction		Showing any manner of behaviour or interacts with other animal
Stereotypic	Pacing		Showing repetitive walking or running along the same path again and again

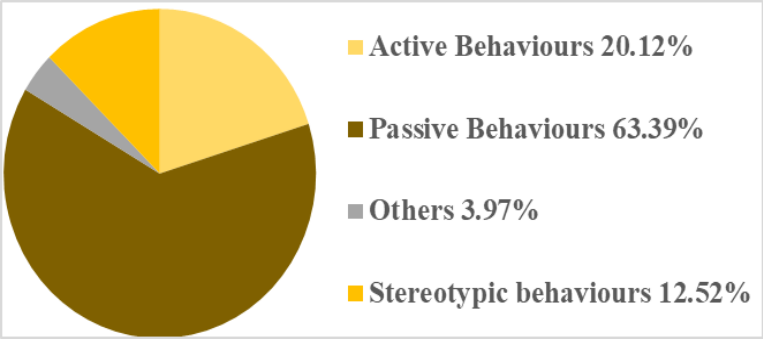

Fig. 2: Percentage of time spent in different behavioural categories by leopard, *Panthera pardus* during monsoon season at Alipore Zoological Garden, Kolkata.

the others category (Table 1). The stereotypic category includes pacing.

Data Analysis

The initial step for the determination of diurnal activity time budget was categorization of activities into various behavioural categories. Then duration for each activity was noted. The obtained data from simple observation on the studied leopard were analyzed and calculated as mean percentage of time, engaged in each activity (Crockett and Ha, 2010). MS-Excel software was used to prepare all the graphical representations required. The experimental data were presented as mean percentage ± standard error (SE). For the comparison of different activity patterns among the three seasons as well as the studied hours, one-way analysis of variance (ANOVA), followed by Duncan's multiple range tests (DMRT) was performed for multiple comparisons at the significance level of 0.05.

Results

A total of 11,200 min of data of diurnal activity of leopard (*Panthera pardus*) were collected for the present study from each of the three seasons. The data was analyzed and presented as a percentage of time spent in different activities by the leopard. The activities performed by the leopard, were divided into 4 categories, active, passive, others and stereotypic. Active category includes feeding of offered feed, eating grasses, crouch, drinking, jumping, climbing, walking, running, aggressive, scratching on object, urine spraying, defecation, alert, sniff, exploring whereas passive category consists of standing, sitting, sitting erect, resting awake, sleeping, yawning, licking itself, rubbing, rolling over, and other behavioural category includes vocalization, panting, human interaction, animal interaction. Pacing was the only stereotypic behaviour displayed by the studied leopard.

Diurnal activity budget in different behavioural categories during monsoon season (*Fig. 2*)

During the observed monsoon season, the leopard primarily engaged in passive behavior, accounting for 63.39% of its time, followed by active behavior at 20.12%, and stereotypic behaviors at 12.52%. Other activities constituted only 3.97% of its observed diurnal time.

Diurnal activity budget in different behavioural categories during winter season (*Fig. 3*)

The leopard predominantly exhibited passive behaviors, accounting for 42.18% of its diurnal time. Activities under other behavioural category were performed for 23.10% of the time, followed by active behaviors (18.55%), and stereotypic activities (16.17%).

Diurnal activity budget in different behavioural categories during winter season (*Fig. 4*)

During summer season, the leopard spent nearly half of their time in passive behavior (47.08%), followed by stereotypic activities (6.05%), active behaviors (22.30%), and activities under the other

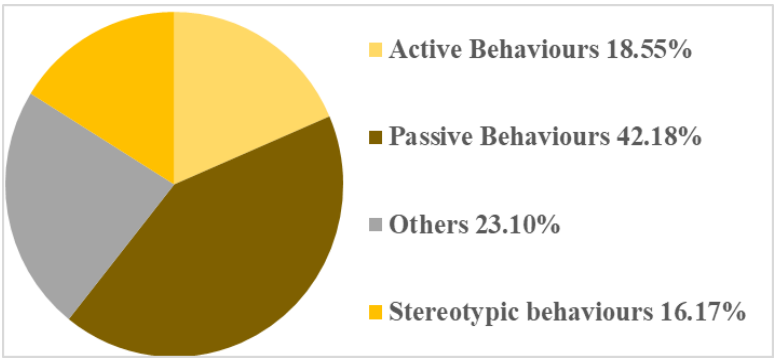

Fig. 3: Percentage of time spent in different behavioural categories by leopard, *Panthera pardus* during winter season at Alipore Zoological Garden, Kolkata.

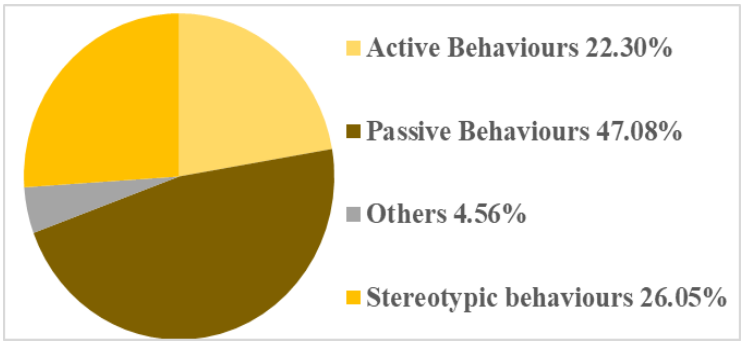

Fig. 4: Percentage of time spent in different major behavioural categories by leopard, *Panthera pardus* during summer season at Alipore Zoological Garden, Kolkata.

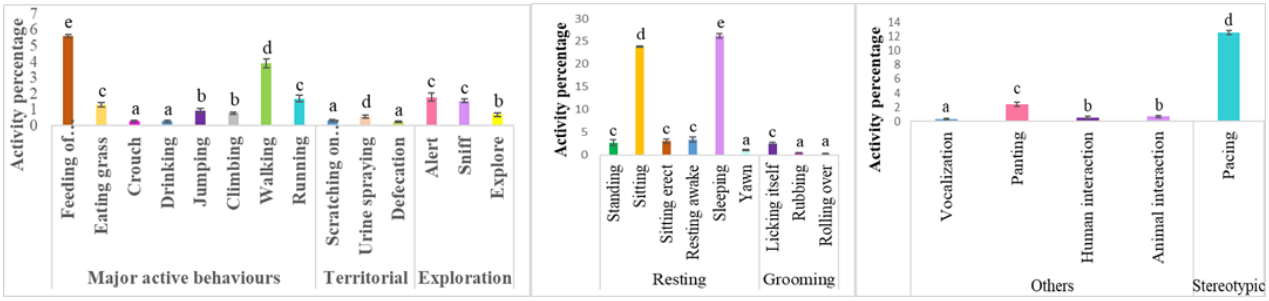

Fig. 5: Percentage of time spent in subtypes of (i) active, (ii) passive and (iii) other, and stereotypic behaviour by leopard, *Panthera pardus* during monsoon season at Alipore Zoological Garden.

behavioural category (4.56%).

Diurnal activity budget in different behavioural subtypes during monsoon season (*Fig. 5*)

During the monsoon season, the leopard was found to be spending significantly higher percentage of time in feeding of offered feed (5.63±0.11) ($p<0.05$; DMRT), followed by walking (3.93±0.28), under the active behaviors. Values for the time spent in alertness, sniffing, running, and eating grasses activities showed no significant variation (DMRT). The studied leopard devoted less time in defecation, drinking, and scratching on objects ($p<0.05$). Among passive behaviors, the leopard spent the majority of its time sleeping (26.23±0.47) ($p<0.05$; DMRT), followed by sitting (23.81±0.17), while the lower mean value was observed for rolling over activity (0.24±0.12). In other activities, panting was significantly higher (2.42±0.33) ($p<0.05$; DMRT), whereas vocalization was lower (0.30±0.10) significantly. The leopard

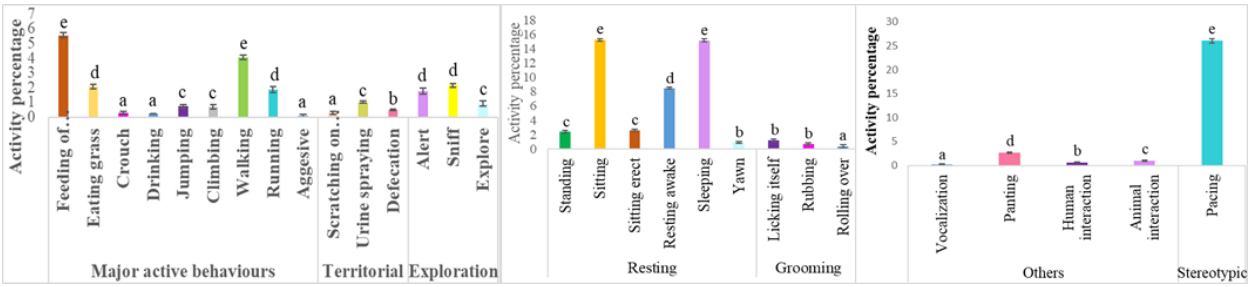

Fig. 6: Percentage of time spent in subtypes of (i) active, (ii) passive and (iii) other, and stereotypic behaviour by leopard, *Panthera pardus* during winter season at Alipore Zoological Garden.

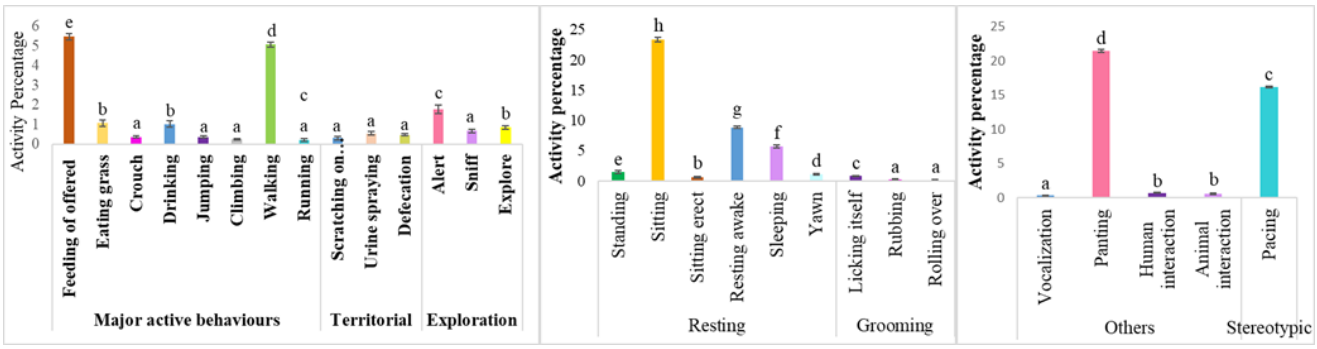

Fig. 7: Percentage of time spent in subtypes of (i) active, (ii) passive and (iii) other and, stereotypic behaviour by leopard, *Panthera pardus* during summer season at Alipore Zoological Garden.

was found to be involved in stereotypic activity, pacing with 12.52% of its time.

Diurnal activity budget in different behavioural subtypes during winter season (*Fig. 6*)

The leopard allocated significantly more time to the feeding of offered feed (5.55±0.18), followed by walking (4.07±0.17) under the active behaviors during the winter season ($p<0.05$; DMRT). Eating grasses, running, alertness, and sniffing showed no significant variation (DMRT). While the leopard dedicated less of the time in drinking, scratching on objects, and aggressive behaviors, respectively. Under the passive behaviors, the studied animal spent maximum time in sitting (15.22±0.18) and sleeping (15.16±0.22), followed by resting awake (8.50±0.12), while rolling over (0.38±0.20) was the significantly less frequent activity. Among the other activities, panting was significantly higher (2.66±0.13), followed by animal interaction (1.01±0.14), human interaction (0.65±0.10) and vocalization (0.24±0.12) ($p<0.05$; DMRT).

Diurnal activity budget in different behavioural categories during summer season (*Fig. 7*)

During the summer season, under the active behaviours, feeding of offered feed (5.48±0.17) was the most prevalent activity shown by the leopard ($p<0.05$; DMRT), followed by walking (5.08±0.13). Under exploration activities, the leopard remained alert for most of the time (1.78%), followed by exploring object (0.85±0,09), and sniffing (0.67±0.08) ($p<0.05$; DMRT).

Among passive behaviors, sitting (23.31±0.37) was significantly higher ($p<0.05$; DMRT), followed by resting awake (8.81±0.16) and then sleeping (5.71±0.23), while the rolling over activity was noted with least mean value (0.12±0.07). In stereotypic behaviour, pacing was noticed with 16.17%. In other behaviors, panting exhibited with significantly high value (21.45±0.19) ($p<0.05$), whereas vocalization showed lower value (0.34±0.07).

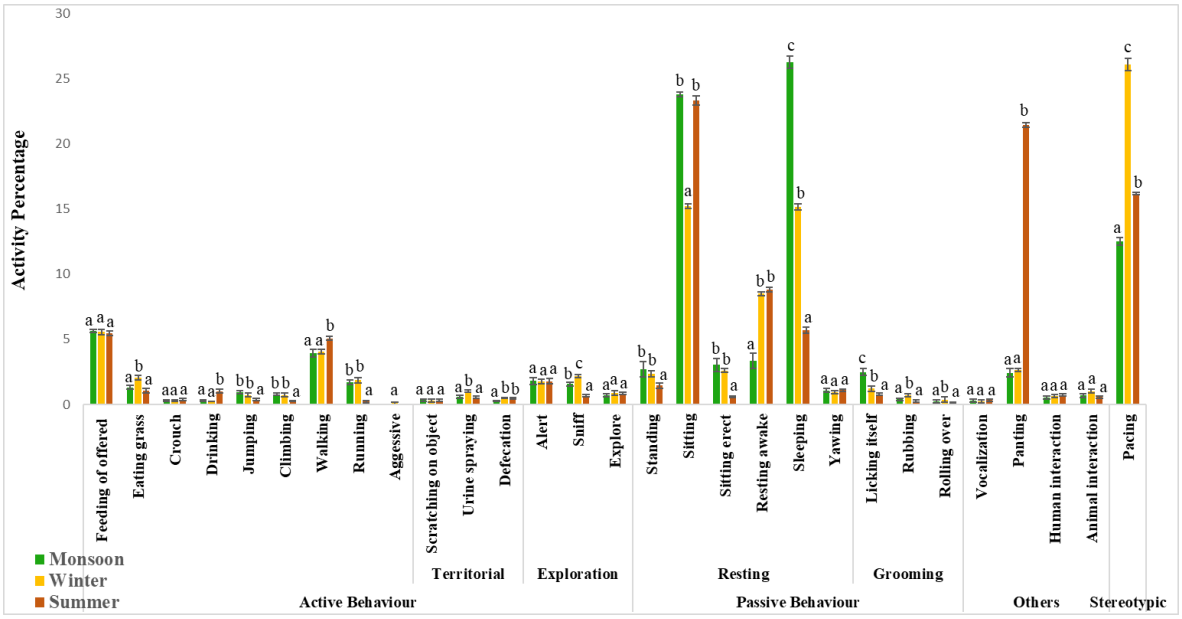

Fig. 8: Percentage of time spent in different behavioural categories by leopard, *Panthera pardus* in three different seasons at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after two way ANOVA.

Comparison of diurnal activity budget of leopard among seasons (*Fig. 8*)

When data of activity budget were compared among the three studied seasons, it was observed that the leopard exhibited consistent feeding behavior across all the seasons, while grass consumption (2.06±0.16) was notably higher in winter than summer and monsoon (p<0.05; DMRT). Drinking (1.03±0.15) and walking (5.08±0.13) peaked during summer (p<0.05; DMRT), while activities like jumping, climbing, and running were significantly less common during this season. Aggressive behavior (0.09±0.09) was observed only in winter. The mean value of defecation (0.50±0.04) was found higher in winter (p<0.05), whereas significantly lower during the monsoon season. Under the territorial activity, urine spraying (1.03±0.07) was maximum in winter (p<0.05; DMRT), while scratching on object did not vary significantly among the seasons. Under exploration behaviour, sniffing was noted more in winter and less in summer, while alertness and exploring object activities did not show any significant variation among the seasons (DMRT). Regarding passive behaviors, sleeping (26.23±0.47) was more in monsoon (p<0.05; DMRT). The activities such as standing (1.47±0.21), sitting erect (0.60±0.07), and sleeping (5.71±0.23) were less frequent in summer, while sitting (15.22±0.18) during winter and resting awake (3.37±0.59) during monsoon (p<0.05; DMRT). Yawning occurred at consistently low rates across all the seasons. Under the grooming behaviours, licking was more frequent (2.5±0.26) in the monsoon and less (0.79±0.07) in summer (p<0.05; DMRT). Rubbing (0.71±0.12) and rolling over (0.38±0.20) activities were more common in winter (p<0.05; DMRT). Among other activities, panting (21.45±0.19) was noticed significantly maximum in summer (p<0.05; DMRT), while the remaining activities like vocalization, human and animal interactions varied insignificantly among the three studied seasons (DMRT).

Hourly activity time budget of leopard during monsoon season (*Table 2*)

The results of hourly activity budget of monsoon season indicated that under the active behaviors, feeding of offered feed, was observed only from 16:00 h to 17:00 h, while grass eating was found throughout the day, peaking in the first hour

Table 2: Mean percentage of hourly activity pattern of leopard, *Panthera pardus* from 10:00h to 17:00h during monsoon season at Alipore Zoological Garden, Kolkata

Behavioural Categories	**Behaviours**	**Hours**						
		10:00-11:00	**11:00-12:00**	**12:00-13:00**	**13:00-14:00**	**14:00-15:00**	**15:00-16:00**	**16:00-17:00**
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	39.44
	Eating grasses	2.92	0.69	1.53	0.69	1.53	0.97	0.83
	Crouch	0.00	0.00	0.69	0.56	0.69	0.00	0.00
	Drinking	0.00	0.00	0.42	0.83	0.69	0.00	0.00
	Jumping	0.97	0.56	0.83	0.42	1.39	1.67	0.83
	Climbing	1.67	0.69	0.56	0.69	0.83	0.69	0.42
	Walking	5.83	3.47	3.75	2.22	3.89	4.31	4.03
	Running	1.81	1.11	1.11	0.69	1.53	2.78	2.92
	Aggressive	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Scratching on object	0.42	0.00	0.28	0.00	0.28	0.97	0.42
	Urine spraying	1.39	0.00	1.11	0.97	0.42	0.14	0.00
	Defecation	0.00	0.00	1.53	0.00	0.28	0.00	0.00
	Alert	0.69	0.83	1.39	2.08	0.83	3.61	3.19
	Sniff	2.08	1.67	1.53	1.25	1.39	1.53	1.53
	Explore	0.69	0.56	1.25	0.14	1.11	0.56	0.56
	Standing	4.72	2.64	2.08	2.64	3.19	1.81	1.94
	Sitting	33.19	31.11	25.28	19.03	25.42	20.69	11.94
	Sitting erect	3.33	1.94	2.36	2.22	2.92	4.72	3.75
	Resting awake	3.19	8.47	4.31	4.31	1.67	0.56	1.11
	Sleeping	12.36	31.81	34.31	50.83	30.00	16.94	7.36
	Yawn	2.22	0.97	0.83	1.25	0.97	1.39	0.00
	Licking itself	3.89	1.39	2.50	2.92	1.94	3.33	1.53
	Rubbing	0.83	0.14	0.28	0.14	0.69	0.42	0.28
	Rolling over	0.42	0.00	0.69	0.00	0.14	0.00	0.42
Others Behaviours	Vocalization	0.14	0.00	0.14	0.00	0.28	0.69	0.83
	Panting	5.56	4.31	2.92	2.08	0.69	0.83	0.56
	Human interaction	0.00	0.00	0.00	0.00	0.14	1.11	2.64
	Animal interaction	0.00	0.56	0.00	0.00	1.53	1.81	0.97
Stereotypic	Pacing	11.67	7.08	8.33	4.03	15.56	28.47	12.50

(10:00 h-11:00 h). Aggressive behavior was absent during the monsoon season. Drinking activity was noted from 12:00 h to 15:00 h and reached peak from 13:00 h to 14:00 h. The active behaviors, like jumping, scratching and alertness activities were found to occur with high frequency from 15:00 h to 16:00 h, while climbing, walking, urine spraying and sniffing from 10:00 h to 11:00 h. The leopard spent maximum time for the running activity from 16:00 h to 17:00 h. The peak hour of exploring and defecation activities was from 12:00 h to13:00 h. Passive behaviors such as standing, yawning, licking and rubbing were occurred with maximum rate from 10:00 h to 11:00 h. Sitting predominated throughout the day with the highest frequency at 10:00 h to 11:00 h, followed by a consistent sleeping with the peaking at 13:00 h to14:00 h. The peak hour of sitting erect, resting awake and rolling over activities were from 15:00 h to 16:00 h, 11:00 h to 12:00 h and 12:00 h to 13:00 h, respectively. Among the other behaviours, panting was highest from 10:00 h to 11:00 h, followed by 11:00 h to12:00 h. Human interaction started at 14:00 h and gradually increased with the highest frequency at the last hour of the observation period. The stereotypic behaviour, pacing reached peak from15:00 h to 16:00 h, while the lowest was found from 13:00 h to 14:00 h.

During the monsoon season, from 10:00 h to 11:00 h, within active behaviours, walking had the highest mean value, followed by eating grasses, sniffing, running, climbing activity. Drinking and crouching were not observed during this time interval. In the subsequent hours, from 11:00 h to 12:00 h and 12:00 h to 13:00 h, peak values of walking were observed, followed by sniffing. From 13:00 h to 14:00 h, the highest time was spent for the walking, followed by alertness activity. Similarly, as in 1st four hours of observation period (10:00 h to 14:00 h), walking was the highest followed by running from 14:00 h to 15:00 h, alertness from 15:00 h to 16:00 h. In the last hour of the observational study (16:00 h to 17:00 h), most of the time was spent in the feeding of offered feed, followed by walking, alertness and running activity. In the first and last two hours of observation, sitting was the most dominant activity, followed by sleeping, while an opposite trend was found from the 11:00 h to 15:00 h where sleeping dominated over the sitting activity. Among the other behaviour category, panting was noticed to occur with higher rate in the first four hours of observation, while human interaction in the last hour of observation and animal interaction was the most frequent behavior at 14:00 h to 16:00 h.

Hourly activity time budget of leopard during winter season (*Table 3*)

During the winter season, under the active behaviors, feeding of offered feed was only observed during the last hour of observation (16:00 h to 17:00 h). The leopard spent maximum time for the eating grasses, crouching and drinking from 13:00 h to 14:00 h, while for the jumping, climbing, walking and running from 15:00 h to 16:00 h. The first two hours and last hour were the peak hours for the exploration activity, while the last two hours for the alertness and scratching activities. Urine spraying, defecation and sniffing were occurred at high rate from 12:00 h to 13:00 h, 15:00 h to 16:00 h and 10:00 h to 11:00 h, respectively. Aggressive behaviour was only noticed from 12:00 h to 13:00 h and 16:00 h to 17:00 h with the higher rate at the last hour of the observation. Under the passive behaviors, standing and self-licking peaked from 12:00 h to 13:00 h. The mean value of sitting was highest in the fourth hour (13:00 h to 14:00 h), whereas sleeping and yawning peaked in the fifth hour (14:00 h to 15:00 h) and last two hours (15:00 h to 17:00 h) of the observational study. Peak values of sitting erect were observed from 14:00 h to 15:00 h and 16:00 h to 17:00 h (3.75%). Rubbing was almost consistent throughout the all observed hours of the day but slightly peaked in the last hour of observation (16:00 h to 17:00 h). Other behavioral activities, panting was found to reach peak from 10:00 h to 11:00 h and 15:00 h to 16:00 h (3.47%), whereas the remaining activities like vocalization and animal and human interaction occurred at high frequency in the last hour of the

Table 3: Mean percentage of hourly activity pattern of leopard, *Panthera pardus* from 10:00h to 17:00h during winter season at Zoological Garden, Kolkata

Behavioural Categories	Behaviours	Hours						
		10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	38.89
	Eating grasses	1.94	2.22	2.22	2.64	0.56	2.36	2.50
	Crouch	0.28	0.00	0.42	1.25	0.00	0.00	0.14
	Drinking	0.00	0.00	0.14	1.53	0.00	0.00	0.00
	Jumping	0.28	0.56	0.69	1.25	0.56	1.53	0.28
	Climbing	0.42	0.56	0.56	1.25	0.42	1.25	0.56
	Walking	5.28	3.06	5.56	4.31	2.22	5.69	2.36
	Running	1.81	1.39	1.25	1.81	0.97	3.19	2.64
	Aggressive	0.00	0.00	0.14	0.00	0.00	0.00	0.56
	Scratching on object	0.28	0.14	0.00	0.00	0.28	0.69	0.69
	Urine spraying	1.53	0.00	1.81	1.67	0.00	1.53	0.69
	Defecation	0.00	0.00	1.67	0.00	0.00	1.81	0.00
	Alert	1.94	1.67	1.25	1.67	1.39	2.22	2.22
	Sniff	3.75	2.22	2.22	1.53	1.39	2.50	1.53
	Explore	1.25	1.25	1.11	0.56	0.14	0.83	1.25
	Standing	1.81	2.50	3.33	2.36	1.67	3.19	1.81
	Sitting	11.39	19.44	9.03	22.64	16.11	21.53	6.39
	Sitting erect	1.94	1.94	2.64	0.97	3.75	3.19	3.75
	Resting awake	5.83	9.72	7.36	7.36	13.06	13.33	2.78
	Sleeping	1.67	13.06	31.39	17.22	32.08	6.11	4.58
	Yawn	0.28	0.97	0.14	1.11	0.97	1.53	1.53
	Licking itself	1.39	0.56	1.53	1.39	1.25	1.39	0.97
	Rubbing	0.42	0.28	0.14	0.69	0.42	1.11	1.94
	Rolling over	0.14	0.00	0.69	0.42	0.14	0.42	0.83
Others Behaviours	Vocalization	0.14	0.00	0.00	0.00	0.28	0.00	1.25
	Panting	3.47	2.50	1.39	2.50	2.92	3.47	2.36
	Human interaction	0.14	0.00	0.00	0.00	0.28	1.11	3.06
	Animal interaction	0.69	0.42	0.83	1.11	0.97	1.11	1.94
Stereotypic	Pacing	51.94	35.56	22.50	22.78	18.19	18.89	12.50

observation. The leopard spent most of its time in stereotypic activity, pacing in the first hour of observation (10:00 h to 11:00 h), followed by the second hour of observation (11:00 h to 12:00 h).

During the winter season, when activity budget was compared among the different hour of day, it was observed that under the active behavioural category, walking was the predominant activity for all the studied hours except the last hour of observation, when feeding of offered feed was the dominant activity. For the first three hours of the observation period, after walking, sniffing was observed with higher rate, while from 14:00 h to 15:00 h, alert and sniffing. Running occurred with the second highest rate from 15:00 h to 16:00 h and 16:00 h to 17:00 h after the walking and feeding of offered feed, respectively. In the initial two hours of observation (from 10:00 h to12:00 h), no instances of drinking or aggressive behaviors were noted and crouching, jumping, and scratching occurred at the lowest frequency (0.28%). Among all the passive behaviours, the leopard spent most of the time in sitting, followed by resting awake for the first (10:00 h to 11:00 h) and second last (15:00 h to 16:00 h) hour of observation, while sitting followed by sleeping for the second (11:00 h to 12:00 h), fourth (13:00 h to 14:00 h) and last hour (15:00 h to 16:00 h) of observational period. Whereas an opposite trend of result was noted from 12:00 h to 13:00 h and 14:00 h to 15:00 h, where the sleeping occurred at higher rate, followed by sitting activity. Under the other behavioural category, panting was found the most frequent behaviour, followed by animal interaction during the observational hours except the last hour where human interaction was the most dominant activity, followed by panting activity.

Hourly activity time budget of leopard during summer season (*Table 4*)

Throughout the observation period of the summer season, the leopard exhibited a distinct pattern of behaviours. Under the active behaviors, feeding of offered feed was notably absent except for the last hour (16:00 h to 17:00 h), while the eating grasses, walking, urine spraying and defecation activities reached peak from 10:00 h to 11:00 h, alertness from 11:00 h to 12:00 h, crouching and drinking from 13:00 h to 14:00 h, climbing, scratching object, sniffing and exploring activities from 15:00 h to 16:00 h, and running from 16:00 h to 17:00 h. Among the different diurnal hours, passive behaviours like standing, sitting erect and licking itself was occurred at higher rate from 10:00 h to 11:00 h, sitting from 12:00 h to 13:00 h, sleeping from 13:00 h to 14:00 h, resting awake from 14:00 h to 15:00 h, yawning from 15:00 h to 16:00 h and sitting erect and rolling over from 16:00 h to 17:00 h. All the observed activities under the other behaviours category were noted to happen at maximum frequency from 16:00 h to 17:00 h, except the panting activity which occur at higher rate from 12:00 h to 13:00 h. Stereotypic behaviour, pacing reached the highest value at the first hour of the observation, followed by the last hour of observation.

When data were compared within hours, among the different activities of the active behavioural category, it was found that walking was the most time spent behaviour displayed by the leopard for the first two hours and the fifth and sixth hour of the observational period. After walking the leopard spend more time in eating grasses at the first hour, alertness at the second and fifth hour, exploration at the sixth hour of the diurnal study period. From 12:00 h to 13:00 h, the studied animal devoted maximum time in alertness activity, followed by the walking activity, while from 13:00 h to 14:00 h in drinking activity, followed by walking and from 16:00 h to 17:00 h in feeding of offered feed, followed by walking activity. Among the passive behaviours, sitting was found dominant for all the studied hours, followed by standing for 10:00 h to11:00 h, sleeping for 13:00 h to 14:00 h, yawning for the last hour and resting awake for the second, third, fifth and sixth hour of the observational period. When other behavioural category was considered, it was noticed that the leopard dedicated most time in panting activity for all the diurnal studied hours,

Table 4: Mean percentage of hourly activity pattern of leopard, *Panthera pardus* from 10:00h to 17:00h during summer season at Zoological Garden, Kolkata

Behavioural Categories	Behaviours	Hours						
		10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	38.33
	Eating grasses	4.44	0.00	0.00	0.14	0.28	1.53	1.11
	Crouch	0.00	0.00	0.00	1.67	0.00	0.97	0.00
	Drinking	0.00	0.00	0.00	4.86	0.00	2.36	0.00
	Jumping	0.14	0.00	0.00	0.14	0.42	0.97	0.97
	Climbing	0.14	0.00	0.00	0.00	0.14	0.97	0.56
	Walking	8.89	5.69	1.53	4.44	2.78	5.69	6.53
	Running	0.00	0.00	0.00	0.14	0.28	0.28	0.83
	Aggressive	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Scratching on object	0.14	0.00	0.00	0.28	0.00	1.11	0.69
	Urine spraying	1.67	0.00	0.56	0.00	0.14	1.53	0.00
	Defecation	1.81	0.00	0.00	0.00	0.97	0.28	0.28
	Alert	1.39	3.19	1.81	1.25	1.11	2.08	1.67
	Sniff	1.39	0.28	0.00	0.42	0.00	1.67	0.97
	Explore	0.00	1.25	0.00	0.69	0.56	1.81	1.67
	Standing	5.69	1.67	0.28	1.25	0.14	0.56	0.69
	Sitting	13.61	26.81	32.22	25.00	31.39	27.08	7.08
	Sitting erect	1.11	0.56	0.00	0.42	0.00	0.97	1.11
	Resting awake	0.69	8.89	8.47	11.67	21.81	9.86	0.28
	Sleeping	1.11	1.67	5.69	12.22	12.08	6.81	0.42
	Yawn	0.42	0.42	0.83	0.56	1.67	2.50	1.39
	Licking itself	1.67	0.83	0.69	0.56	0.56	0.97	0.28
	Rubbing	0.00	0.14	0.00	0.14	0.00	0.83	0.69
	Rolling over	0.00	0.00	0.00	0.14	0.14	0.00	0.56
Others Behaviours	Vocalization	0.14	0.00	0.00	0.00	0.00	0.97	1.25
	Panting	10.14	31.11	42.50	26.81	16.67	13.47	9.44
	Human interaction	0.56	0.28	0.00	0.42	0.42	0.42	3.06
	Animal interaction	0.69	0.42	0.28	0.14	0.28	0.28	1.94
Stereotypic	Pacing	44.17	16.81	5.14	6.67	8.19	14.03	18.19

followed by animal interaction activity for the first three hours and human interaction for the last four hours of the diurnal study period.

Comparison of hourly activity budget of leopard (*Fig. 9*)

From10:00 h to11:00 h

When comparing the mean time spent percentages of different activities displayed by the studied leopard among the three seasons, it was observed that active behaviors like walking (5.83%) and eating grasses (4.44%) were most prevalent during the summer season, followed by the monsoon and then in winter. Jumping and climbing were more frequent in the monsoon compared to winter and summer. Defecation was only observed during summer in the first hour, whereas sniffing, alertness and exploration were most common in winter.

Passive behaviors such as sitting (33.19%), sleeping (12.36%), and yawning (2.22%) were significantly higher during the monsoon season compared to other seasons. Resting awake (0.69%) was least observed in summer during the initial observation hour. All the grooming activities such as licking itself, rubbing and rolling over were found more during the monsoon season. Among other behavioural category, panting was more in monsoon and human interaction in summer. When considering the stereotypic behaviour, pacing (51.94%) occurred at higher rate during the winter season than the other two seasons.

From11:00 h to 12:00 h

When comparing the data across seasons, it was observed that during the second hour of observation, the highest time was spent in walking (5.69%) in the summer season. Time spent for the active behavior like eating grasses and running were maximum during winter, while eating grasses, running, jumping, climbing and scratching object were not found in the second hour of observation during summer. Under the passive behaviour, sitting (31.11%), sleeping (31.80%) and standing (2.64%) were most frequent during the summer, while resting awake during the winter. The leopard predominantly engaged in panting during summer (31.11%), while spending the least time in winter (2.5%). Pacing was found to be occurred in higher rate during winter (35.55%) and less during monsoon (7.08%).

From12:00 h to13:00 h

The study revealed that the time spent in active behaviors, particularly walking, eating grasses, running, sniffing, urine spraying and defecation were occurred at higher rate during winter. The activities like eating grasses, crouching, drinking, jumping, climbing, running, sniffing, exploring and scratching object, and defecation were absent in the third hour of observation during the summer season. Alertness was most prevalent during summer (1.80%), while crouching, drinking, jumping and exploring object during monsoon. Under the passive behaviors, sitting (32.22%) and resting awake (8.47%) were most frequent during summer. Sleeping was more during the monsoon, while standing and sitting erect during winter. Under the grooming sub-category, licking and rubbing occurred with the highest rate during the monsoon, followed by winter. Almost half of the time of third hour of observation, was spent in panting (42.5%) activity by the leopard during the summer season, while the stereotypic behaviour, pacing (22.5%) was more frequent during winter.

From13:00 h to14:00 h

Among all the active behaviors, drinking was most prevalent in summer (4.86%), followed by winter (1.52%). During the fourth hour of observation, the leopard predominantly engaged in walking (4.44%) in summer, while climbing (0.69%), jumping (0.41%), and running occurred in the monsoon (0.69%). Alertness was found at maximum frequency during summer, whereas sniffing and urine spraying were most frequent during winter. In the passive behaviors, the highest frequency of sleeping and self-licking was observed during the monsoon, followed by winter and then summer. Yawning (1.25%), standing (2.64%), and sitting erect (2.22%) were most

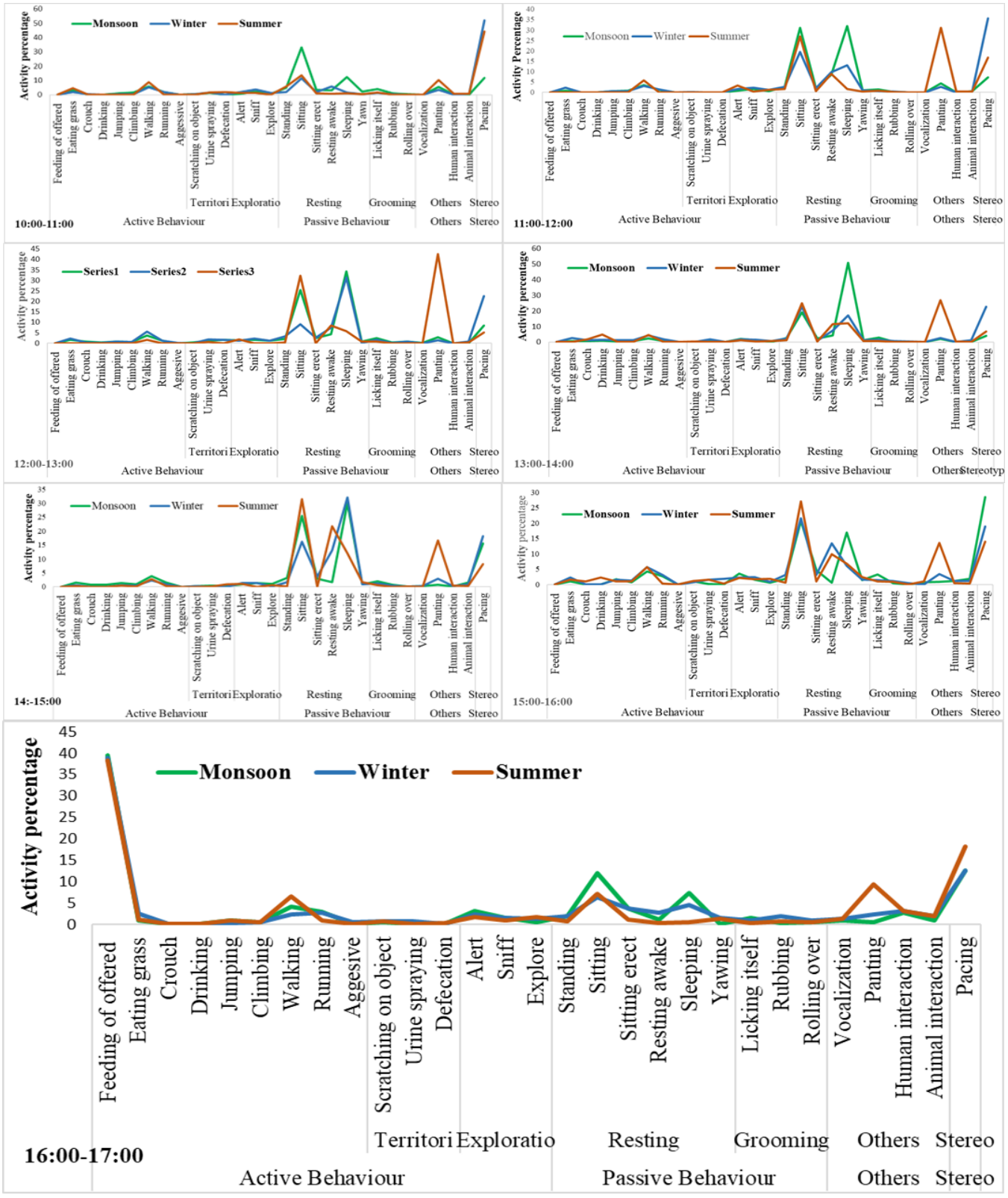

Fig. 9: Activity budget of leopard, *Panthera pardus* in different seasons from 10:00h to 17:00h at Alipore Zoological Garden, Kolkata.

prevalent in the fourth hour of observation during the monsoon. Regarding other behavioural category, panting showed increased frequency during summer (26.80%) and the least during the monsoon (2.08%). Pacing was the most frequent stereotypic behaviour of fourth hour of winter (22.78%) and least during the monsoon (4.03%).

From14:00 h to 15:00 h

During the fifth hour of observation, active behaviors such as running, walking, climbing, jumping, eating grasses, urine spraying and exploring object occurred at high frequency during the monsoon, while the least frequency of walking and exploring object were noted during winter and running, jumping, climbing and eating grasses during summer. Urine spraying (0.42%) peaked during monsoon, whereas defecation during summer (0.97%). Alertness reached peak in the fifth hour of winter. When considering the passive behaviours, in the fifth hour, sitting and resting awake peaked during summer while the standing during monsoon and, sleeping and sitting erect during winter. The leopard spent more time in panting during summer (16.67%) while less time during the monsoon (0.69%). The stereotypic behaviour, pacing was found to occur at high frequency in the fifth hour during winter (18.19%) and in less frequency during summer (8.19%).

From15:00 h to 16:00 h

When analyzing all the active behaviors of the sixth hour of observation, it was found that the leopard spent more time in running, climbing and eating grasses during the winter season, while in jumping during monsoon. Under the exploration sub-category, alertness was more in monsoon, sniffing in winter and exploration in summer. Under the passive behaviour category, in the sixth hour, sleeping and sitting erect showed a considerable high value during the monsoon season, while standing and resting awake during winter and, sitting and yawning during summer. Undergrooming sub-category, in sixth hour, licking itself was noted more during the monsoon season, while rubbing during winter. Regarding the other behaviours category, panting and vocalization were the most frequent activities of summer, while animal interaction during monsoon. The stereotypic behaviour, pacing was noted to occur at high rate during the monsoon season (28.47%), followed by winter (18.87%), and summer (14.03%).

From16:00 h to 17:00 h

When comparing the mean time spent percentage of the leopard among the studied seasons within the last hour of observation, it was noted that during the summer season, the leopard spent maximum time in jumping (0.97%), and walking (6.53%), while during monsoon in running (2.92%). Aggressive behaviour and crouching were only noted in winter season in last hour. The leopard spent the maximum time (38.33% to 39.44%) of the last hour of observation in feeding of offered feed in all the three studied season with slightly increased time spent in monsoon. Under the exploration sub-category, in the last observational hour, alertness was more in monsoon, while exploring object in summer. In case of passive behaviors, standing, sitting and sleeping were most frequent during the monsoon in the last hour, whereas resting awake and yawning in winter. Under the grooming sub-category, in the last observation hour, self-licking occurred at high rate during the monsoon season, while rubbing and rolling over during thewinter season. During the summer season, in the last observation hour, panting (9.44%) and the stereotypic behaviour, pacing (18.19%) was noticed to occur at high frequency.

Discussion

Behavior analysis plays an important role in animal welfare researches as it identifies the factors related to stress and suffering of zoo animals caused due to captivity. Unlike leopards living in the wild, leopards of zoos often meet strangers, which can influence their natural behaviors and thus responsible for developing stereotypic behaviours, the repetitive and seemingly purposeless behaviour of captive

animals (Davey, 2007; Morgan and Tromborg, 2007; Mason *et al*., 2007). Captivity can alter behaviors, which is a scientific problem. Animals often alter their behaviors in response to changes in the environment. Prior studies consistently highlighted the negative influences of captivity on the displayed behaviours of zoo animals (Mallapur and Chellam, 2002). Excessive inactivity of captive animals in zoo might be the cause of no or insufficient enrichment tools and inadequate size of enclosure (Mallapur and Chellam, 2002). The objective of this study was to develop an ethogram. The present study revealed that leopards in captivity need highly enriched enclosures containing tree covers, pools, stones, and suitable surroundings with less tourist pressure and appropriate veterinary care; those will reduce the frequency of stereotypic behaviours, caused by high stress levels.

Inactive or passive behaviours

The captive leopard spent most of the time resting during the monsoon season followed by winter and then summer. It generally took rest under the shade of trees, branches or in shady areas. Again, in winter the leopard rested in the sunny places of its enclosure. The passive behaviour of the leopard was noted to be disturbed by the noise of tourists, as well as sounds of jaguars and monkeys in the nearby cages. These findings coincided with that of the study conducted on the leopards of Nandankanan Zoological Park (Sethy and Mohapatra, 2020). The leopard contributed nearly 5% of its activity budget on the activities such as walking, running or climbing, thereby less amount of his diurnal time was spent on these active behaviours. A similar observation was noted in some prior studies, carried out on leopards of four different zoos in southern India which reported that captive leopard showed less activity in the enriched enclosures and even lower in unenriched enclosures (Mallapur *et al*., 2002). This inactivity during the day time might be due to the natural habit of leopards (Ngoprasert *et al*., 2007). Not only that, leopards at National Zoological Park, New Delhi, spent a lot of time being engaged in inactive behaviours (58±13%) among which sitting was most common (Gupta *et al*., 2022). Similar findings were recorded in the behaviour of the present studied leopard of Alipore Zoological Garden.

Active behaviours

Leopards in the wild generally exhibits crepuscular behaviour which means they are mostly active in the morning and evening while taking rest during the warmer parts of the day (Schaller, 1972; Bailey, 1993). This pattern of diurnal time expenditure of captive leopards of some zoos of southern India was found to be consistent (Mallapur and Chellam, 2002). A similar observation was documented for the leopards of National Zoological Park, New Delhi during the morning times (Gupta *et al*., 2022). The present study on leopard of Alipore Zoological Garden, followed this pattern of high level of sedentary behaviour during the 1st hour of observation (10:00 h to 11:00 h).

Walking

Walking was the predominant behaviour in this study. The leopard of Alipore Zoological Garden exhibited maximum time walking (5.08 ± 0.13%) which was also observed from a separate study conducted on the leopards of National Zoological Park, New Delhi (5.9% ± 1%). At Parken Zoo, leopards were most often seen walking in the morning hours, especially during the first viewing (e.g., 8:00 h to 9:00 h) whereas, walking speed significantly decreased during the 3rd hour of observation (12:00 h to 13:00 h). In contrast, leopards at Nodens Ark, walked more frequently in the 3rd hour (Apelqvist, 2014). The walking activity of leopard coincided with the findings of these two places. It spent much of its time walking in the 1st hour of observation during the monsoon season whereas, during winter, walking was found to reach the peak value in the 1st, 2nd and 4th hours of observation.

Eating grasses

The consistent behaviour of consuming grass, observed in the studied animal, is crucial as it has

not been documented in previous studies. Mostly, felids eat grasses to digest food or to soothe the stomach. This behaviour displayed by the leopard, could be an indication of maldigestion. Otherwise, it might also be considered as an expression of any abnormal behaviour.

Panting

The leopard displayed frequent panting behaviour during the summer months; the number of occurrences were almost six times higher during summer than monsoon and winter months. Excessive panting recognized by rapid breathing mechanism was a result of overheating which was performed to control its body temperature. As the environmental temperature was much higher during the summer season, the leopard frequently showed panting to release excessive heat from its body and thus preventing itself from overheating in warm environments.

Drinking

It was noted that similar to panting drinking was also more frequent during summer than in winter and monsoon season. This might be an adaptation to protect itself from the scorching heat of the sun. In high temperatures, the leopard lost a lot of water due to panting and increased activity. By drinking plenty of water the animal might have replaced the body fluids lost and thus preventing itself from dehydration.

Aggressive

Wild conspecifics of leopards are generally nomadic individuals that maintain their territory by acting defensively or aggressively against intruders, detecting the arrival or threat of visitors. The captive leopards of Alipore Zoological Garden did not exhibit aggressive behaviour during summer and monsoon, but became slightly aggressive in winter, probably due to greater number of visitors during that season. Stress and anxiety associated with noise and unfamiliar environments of captivity might have further worsen this situation.

Stereotypic pacing

The captive predator generally displayed negative behaviours related to movement which was being influenced by the need for food, finding a mate, protecting the territory, searching and avoiding negative situations (Club and Vickery, 2006). Many studies had shown the prevalence of negative behaviours in wild (Mallapur *et al*., 2002; Clubb and Mason, 2007). Stereotypic activity exceeding 10% of all the activities is generally considered inappropriate for animals in captivity (Broom 1983). In the present study, stereotypic gait of the leopard ranged from 12.52% to 26.05%, which indicated that it was far beyond the acceptable range. Factors such as size, additional equipment, temperature, presence of visitors and keeper behaviour generally had a negative impact on the activities and behaviours of captive animals.

The leopards of the National Zoological Park (New Delhi) showed stereotypic activity during the morning hours of the day (9:00 h to 10:30 h) (Gupta *et al*., 2022). A similar pattern was noted for the leopard of present study, where the studied animal spent maximum time in stereotypic pacing during the initial hours of observation. All 16 leopards kept in four zoos in southern India were observed engaged in anxiety and discomfort before eating. This finding was similar with the present study where the leopard showed increased anxiety, frequent panting, occasional running in the last period of observation just before the feeding time.

The leopard of Alipore Zoological Garden was found to stand at the edge of the gate just before the feeding time from where the approaching keepers were clearly visible. This observation was coincided with the study conducted on leopards of four different zoos of southern India (Sethy and Mohapatra, 2020).

A prior study on leopards of National Zoological Park, New Delhi, revealed that the leopards were found to display an increased pacing activity and also breathed heavily when they saw the food trucks or heard its sound (Gupta *et al*., 2022). Similar observations were

documented from the various studies on big cats (Mohapatra *et al*., 2010, 2014). Following this pattern, leopard of Alipore Zoological Garden showed increased anxiety, panting and sometimes aggressive behaviour towards their keepers when they started to provide the food, and this aggressive behaviour continued until the food was not served completely. The leopard also continued to vocalize when it noticed the zoo keepers, which was also noted in case of the zoo leopards of southern India (Mallapur and Chellam, 2002).

The noise, nuisance activities and proximity of visitorsas well as their presence had a negative impact on the behavior of captive leopard (Hosey and Druck, 1987). Human activities such as shouting, and throwing things at animals could be the cause of disturbing the mental and physical health of the animals in captivity (Venugopal and Sha, 1993). Stress induced by the visitors can cause illnesses of the zoo animals and have a negative impact on captivity programs (Hosey and Druck, 1987). An earlier study report on activity budget of leopards from the four different zoos of southern India, found an increase in stereotypic behaviours during the festival times when the zoos faced a huge tourist pressure (Mallapur and Chellam, 2002). A similar observation was reported by Gupta *et al.* (2022) for the captive leopard of National Zoological Park, New Delhi, where an increased number of visitors in the evening time was found to be associated with the increased rate of its aggressive behavior. In the same way, the leopard of present study showed a higher pacing rate in the winter months compared to the summer and monsoon due to maximal footfall of visitors in the Alipore Zoological Garden during the winter season.

Conclusion

Well-kept conditions have a positive influence on animal behavioral patterns and activity levels. A stereotypic gait is common for the studied leopard kept in captivity at Kolkata's Alipore Zoological Garden. Factors like tree cover, ponds, rocks, caves and good keeper interaction might have an important role in leopard's adaptation to captivity. Although Alipore Zoological Garden had a well-maintained captive enclosure for the leopard, further improvement could alleviate the health of this endangered animal. Captivity remains a priority for animal conservation, thereby animal welfare management should prioritize their well-being by adopting various strategies based on the activity budget and behavioural pattern displayed by the captive leopard. Hence, the present study report might be helpful for the Zoo Authority and there is a need of further studies on diurnal as well as nocturnal activity budget of captive leopard throughout the world for their successful conservation efforts.

Ethical Statement

This is an observational study and no animal or microbes have been sacrificed for this study, hence Ethical Approval not required.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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