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

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Abstract: Diurnal activity pattern and time budgeting of male jaguar (*Panthera onca*) was studied at Alipore Zoological Garden, Kolkata, India, from 10:00 h to 17:00 h between June, 2023 to May, 2024 by using focal sampling method with 33,600 minutes of observations. The study identified twelve active, six resting, six territorial, two exploration, two maintenance, two social, one vocalization and one stereotypic behaviour of jaguar during the observation period. The jaguar showed significant variations in his displayed activities among the seasons and in the different diurnal hours. The study revealed that the jaguar spent most of the time of observational period in stereotypic pacing ($40.81 \pm 0.37\%$) during monsoon whereas, sleeping during summer ($24.15 \pm 0.28\%$) and laying down during winter ($25.08 \pm 0.21\%$). Active behaviours like climbing and walking was noted to occur at high frequency during monsoon while panting and swimming during summer. During monsoon, increased territorial marking was noticed. When considering different diurnal hours, walking was found more from 10:00 h to 16:00 h in monsoon with the highest value from 11:00 h to 12:00 h (12.64%). Among territorial activities, head rubbing occur with high rate in the first hour of observation (1.53%). During winter, from 15:00 h to 16:00 h, scraping ground was the most frequent activity (1.25%) while, lay down reached peak from 13:00 h to 14:00 h (47.64%). During summer, the jaguar was mostly engaged in playing (0.83%) and swimming (4.03%) in the last hour of observation. During monsoon, the frequency of stereotypic behaviour, pacing peaked from 15:00 h to 16:00 h (65.69%). The incidence of higher stereotypic pacing indicates its possible poor mental health and demands further investigation on whether the captive surrounding is the root of this and what to do for maintaining a proper healthy life for the animal.

Keywords: Alipore Zoological Garden, Diurnal activity pattern, Focal sampling, *Panthera onca*, Time budgeting

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Introduction

The jaguar (*Panthera onca*), the third largest species of felid (Johnson and Ivy, 2016) and the

largest cat species of the Americas (Nowell and Jackson, 1996), is one magnificent beast living in

the remote areas of South and Central America, particularly in the Amazon Basin. Due to its charismatic yet camouflagic appearance and powerful bite, this apex predator can be called 'The True King of the Jungle'. The name 'Jaguar' probably comes from the Tupi-Guarani word 'Yaguara' that means wild beast who kills with one leap. This ferocious animal has a muscular, deep-chested body whose size and weight can vary with sex and region. Its body colour varies from pale to tan or reddish yellow with its underside whitish and is covered with rosette like 'spots' with one or more dots. This specific feature helps them blending with the surrounding dense forests. Jaguar is usually a solitary animal which hunts using a stalk and ambush strategy. Its relatively large head and robust canines is the sole reason for its powerful bite. Its limbs are short but massive to adapt with decreased cursorial behaviour and it has padded feet for keeping its movement light. This water loving animal is quite skilful at swimming and likes to play in water specially in dry seasons. Jaguar generally uses roar or grunt as means for long-distance communication.

Populations of jaguars are decreasing at a dangerous rate day by day, currently occurring in only 54% in their historic geographic range (Sanderson *et al.*, 2002). According to IUCN this species is recorded as 'Near Threatened' because of the threats it is facing such as loss of habitat, illegal poaching of prey, trophy hunting, human expansion and killing as retaliation for livestock predation. Hence, in order to conserve this keystone species many initiatives have been taken. Jaguars are kept in captivity in zoos, national parks etc. across the world to pull them away from the verge of being extinct. However, housing these animals keeping their welfare in mind, is a bit challenging. Management of these zoo-housed animals is quite costly. Moreover, Big cats like jaguars either get involved in stereotypic behaviours or do not show any activity. Captive jaguars often differ from the wild ones as captive ones do not need or have the opportunity to exhibit the range of behaviours to survive in the

captivity because of the major difference between the captive environment and the natural wild habitat, one for which they have originally evolved for.

So, in order to improve their life in captive world, there is a need to understand the behaviour pattern and activity budget of the jaguars and thus it could be possible to ensure their overall healthy life. Stereotypic, abnormal behaviours imply the poor welfare of the animals whereas many behaviours are the indicator of good welfare such as playing. Behavioural observation and recording data provide crucial information that allows for the quantification of behavioural events (Powell *et al.*, 1975) and set goals for the further improvement of the animal's life in captivity. Moreover, besides providing useful information about an individual animal's current state of welfare, data can enrich our knowledge on the basic biology of the species and boost up the efforts of *in situ* conservation as well (Crockett and Ha, 2010).

The activity time budget of a jaguar represents its various activity during the observation period. It basically is a means of obtaining information about the proportion of time that a jaguar spends in a specific activity and is crucial for providing baseline data on its behaviour. This aids in testing hypotheses regarding various experimental treatments. The activity time budget makes it easy to identify the difference between the behaviour of the species of interest in captivity and in wild, and also to reach to the root of the problems which are causing such differences. The activity time budget combined with energy cost of different behaviours exhibited by the studied animal, could be useful in estimating the total energy expenditure for that species (Ahamed, 2015; Samarasinghe and Ahamed, 2016).

The data of prior studies on the activity pattern and time budget of zoo jaguars enlighten us with the knowledge that helps to understand the differences in behaviours between the captive and the wild species, especially the stereotypic behaviours. Stereotypic behaviours refer to the

repetitive, invariant actions without any goal or purpose which may develop as a coping mechanism for the inescapable frustration or lack of stimulation. Independent evidence implicated that they are associated with poor welfare (Mason, 1991a). One of the most common and recognized stereotypic behaviours is pacing which affects the animal both emotionally and physically. As a result of pacing the animal suffers from hair loss, abrasions and sores. Experts suggested that hunting limitations (Clubb and Mason, 2007) or unsuccessful, vain attempts at escape (Clubb and Vickery, 2006) could be the cause behind such behaviour.

For the successful *ex situ* conservation management and captive breeding, there is a need of detailed study of behavioural pattern and activity budget analysis. Earlier very few studies were available on the activity pattern of jaguars in captivity (Knight, 2016; Morris, 2018). Considering the paucity of knowledge about the detailed activity pattern of this species in captivity, the present study was attempted to determine a diurnal activity time budget and the seasonal effect on the activity time budget of the male jaguar kept in Alipore Zoological Garden, Kolkata, India over a period of one year (June 2023-May 2024).

Materials and Methods

Study site

The present study has been conducted at India's oldest zoological park as well as one of the attractive tourist spots, Alipore Zoological Garden (22°32'9.29" N, 88°19'55.39" E), Kolkata, India. Governor General of India, Richard Wellesley established this zoo covering area of about 18.811 ha around the year, 1800. This home of approximately 1,266 animals and about 108 species of mammals, birds and reptiles, was inaugurated on 1st January 1876. Different species of migratory birds are also attracted to this place every winter because of the presence of many water bodies in and around the zoo. Summer season is hot and humid with an average

temperature of 36°C which maximizes up to 43°C. It starts in March and ends in June, till the beginning of Monsoon. On the other hand, winter season tends to continue from December to February with 13°C as average temperature. The minimum temperature during winter goes down to 10°C. Rains lash the city between June and September with a yearly rainfall of about 1641.4 mm.

Study animal

The study animal is a male jaguar named Arya kept in an open enclosure of the zoo. He is around 12 years old. His diet basically includes daily 5 kg buffalo meat in summer and 3 kg in winter. The food is provided by the zoo authority to him twice a day after 4:30 pm.

Enclosure of the animal

The jaguar enclosure (Fig. 1) is about 760.45 sq.m. It is an open-air enclosure situated at the west side of the zoo. The enclosure is surrounded by glass at one side and netted fence at the other three sides. Inside the enclosure, there are many large trees and the ground of enclosure is covered by grasses. It has a water body for the jaguar's drinking and swimming purposes. It also has two two-layered stands for his resting. There is a room with three entry points on the right corner of the enclosure in which the jaguar is offered his feed.

Data collection

For the study on activity pattern of the male jaguar, data were collected from monsoon to summer seasons (12 months study, 4 months from monsoon, 4 months from winter and 4 months from summer). Simple observation was done to estimate the behaviours displayed by the jaguar using unaided eye. Focal sampling method was used (Altmann, 1974). The activities performed by the studied jaguar 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

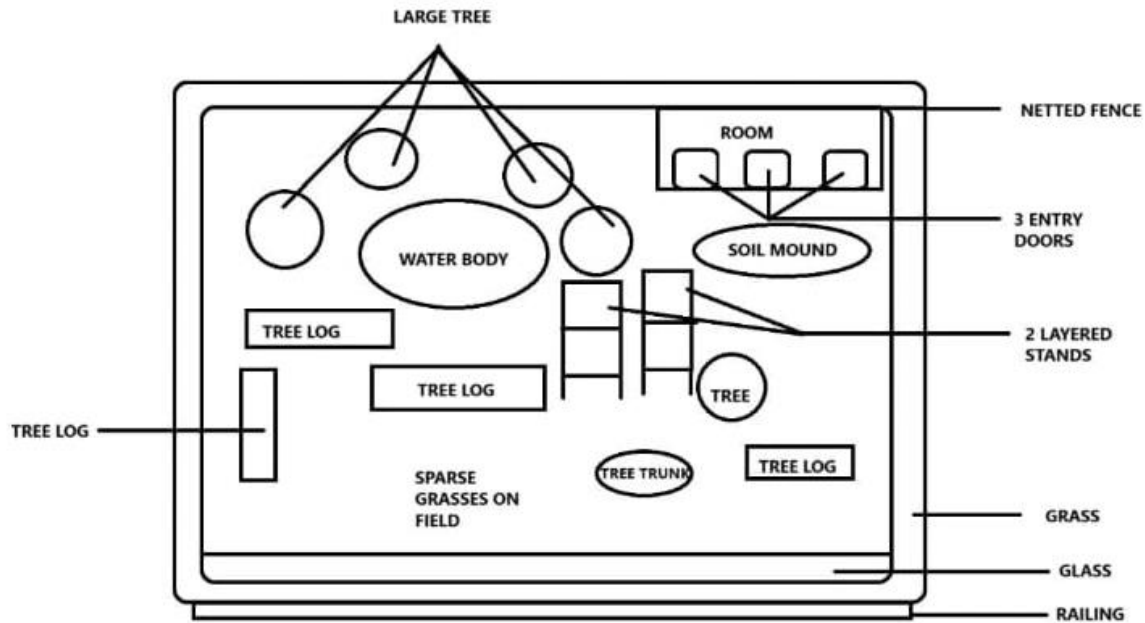


Fig. 1: Layout of jaguar enclosure of Alipore Zoological Garden, Kolkata (based on visual observations during present study).

or environment. Total observation was carried out for 33,600 min.

Ethogram

An ethogram is a catalogue of behaviours constructed by researchers based on the sample examinations of group of animals or individual animals with time. it is advantageous to form an ethogram where different types of behaviour are unbiased, separate and not to overlies with each other. For making an ethogram, a specific and apt name is given to denote each and every behaviour with brief descriptions. An ethogram was constructed for the present study (Table 1) on the basis of prior studies on jaguars (Knight, 2016; Morris, 2018) and initial observations of the current study.

Data Analysis

For the determination of diurnal activity time budget, the initial step was grouping of activities into various behavioural categories. Then duration for each activity was recorded. The obtained data from simple observation on the studied jaguar 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 needed. The experimental data were presented as mean percentage $\pm$ 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 8400 min of data of diurnal activity of jaguar, *Panthera onca* were collected for the present study from each of the three seasons. The data was analysed and presented as percentage of time spent in different activities by the jaguar.

The activities performed by the jaguar, were divided into 8 categories- active, resting, exploration, social, territorial, vocalization, maintenance and stereotype behaviour. Active category includes standing, walking, feeding of offered feed, panting, swimming, climbing etc.

Table 1: Ethogram used for collecting behavioural data of jaguar (*Panthera onca*) in captivity at Alipore Zoo, Kolkata (based on Knight, 2016; Morris, 2018).

Category	Type	Description
Active	Feeding of offered feed	Consumption of offered food items
	Eating grasses	Feeding on grasses of enclosure
	Drinking	Drinking water
	Climbing	Climbing on structures or trees of enclosures
	Swimming	Swimming by holding head and spine out of the water
	Playing	Playing with water or leaves of tree
	Panting	Breathing rapidly
	Stretching	Stretching of whole body
	Walking	Movements quadrupedally
	Running	Changing position at full speed
	Aggressive	Baring teeth, snarling, hissing, charging towards enclosure fence at a target
	Standing	Standing with four feet and with no movement
	Head body shake	Moving the head side by side or shaking the body
Resting	Sitting	Sitting with eyes open
	Sitting erect	Sitting upright
	Lay down	Laying with open eyes
	Resting awake	Sitting in a resting posture keeping head down
	Sleeping	Laying or sitting with closed eyes
	Yawning	Opening mouth wide and inhaling deeply due to boredom or tiredness
Territorial	Body rub	Rubbing length of body against objects
	Head rub	Rubbing head against objects
	Scraping Ground	Scraping the ground with hind paws
	Tree raking	Clawing and scraping trees
	Urine spray marking	Marking territory by discharge of urine
	Defecation	Discharge of faeces from body
Exploration	Looking around	Looking around while walking or sitting
	Sniffing	Taking air via noses for detecting smell
Maintenance	Grooming	Cleaning of body by licking or rubbing any body part with paws
	Rolling	Rolling over on ground
Vocalization	Grunt/Cough	Low pitched calling
Social	Human interaction	Interacting with visitors by staring or grunting
	Animal interaction	Interacting with other animals in the enclosure by chasing
Stereotype	Pacing	Roaming on same path repetitively

whereas resting consists of sitting, laying down, sleeping etc. Looking around and sniffing comes under exploration category. On the other hand, human and animal interaction falls under its social behaviour. Territorial behaviour includes marking by urine spraying, tree raking, body rub, head rub and defecation. Grunting and grooming falls under vocalization and maintenance category,

respectively. Pacing was the one stereotypic behaviour shown by the jaguar.

Diurnal activity budget of jaguar in different behavioural categories during monsoon, winter and summer season

During monsoon, the jaguar spent most of its time in stereotypic activity (40.81%), closely followed

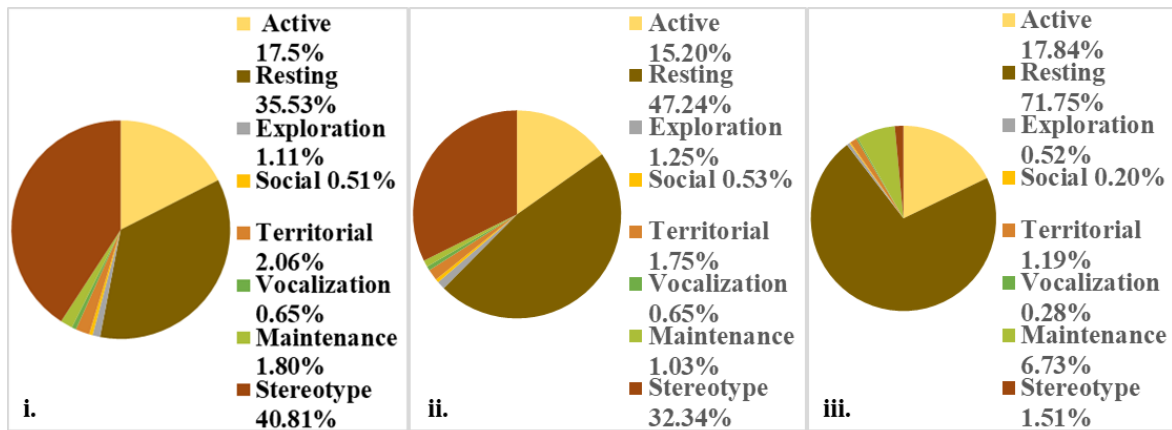


Fig. 2: Percentage of time spent in different behavioural categories by jaguar during monsoon (i), winter (ii) and summer (iii) season at Alipore Zoological Garden, Kolkata.

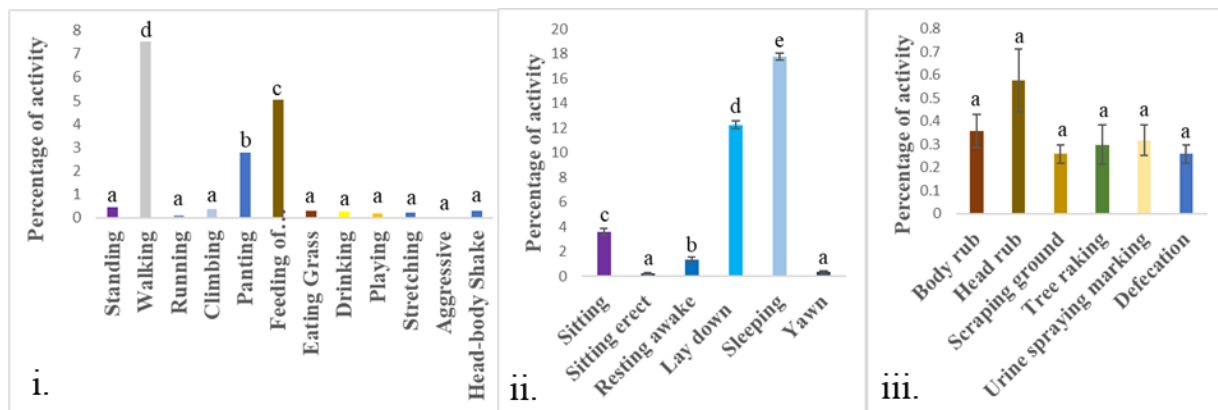


Fig. 3: Percentage of time spent in subcategories of active (i), resting (ii) and territorial (iii) behaviour by jaguar during monsoon season at Alipore Zoological Garden, Kolkata. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P < 0.05$) using DMRT after one-way ANOVA.

by resting behaviour (35.53%). It exhibited active behaviour for 17.5% of the day followed by territorial activity (2.06%), maintenance (1.80%), exploration (1.11%), vocalization (0.65%), social behaviour (0.51%) (Fig. 2).

During winter, the jaguar is engaged in resting activities nearly half of the time (47.24%) of this season. It showed stereotypic behaviour for 32.34% of the time followed by active behaviour (15.20%), territorial marking (1.75%), exploration (1.25%), maintenance (1.03%), vocalization (0.65%), social activities (0.53%).

During summer season, the jaguar predominantly exhibited resting behaviours for 71.75% of its diurnal time followed by active behaviours

(17.84%), maintenance (6.73%), stereotypic activity (1.51%), territorial marking (1.19%), exploration (0.52%), vocalization (0.28%), social activities (0.20%).

Diurnal activity budget of jaguar in different activities during monsoon season

During monsoon season, among active behaviours, walking (7.52 ± 0.21) was found significantly higher ($P < 0.05$; DMRT), followed by feeding of offered feed (5.02 ± 0.12), panting (2.80 ± 0.22), whereas, the lower mean value was observed for aggressive behaviour (0.04 ± 0.05). The studied animal devoted less time in other activities like climbing, drinking, standing, eating grasses, head-body shake, etc. (Fig. 3). When considering the

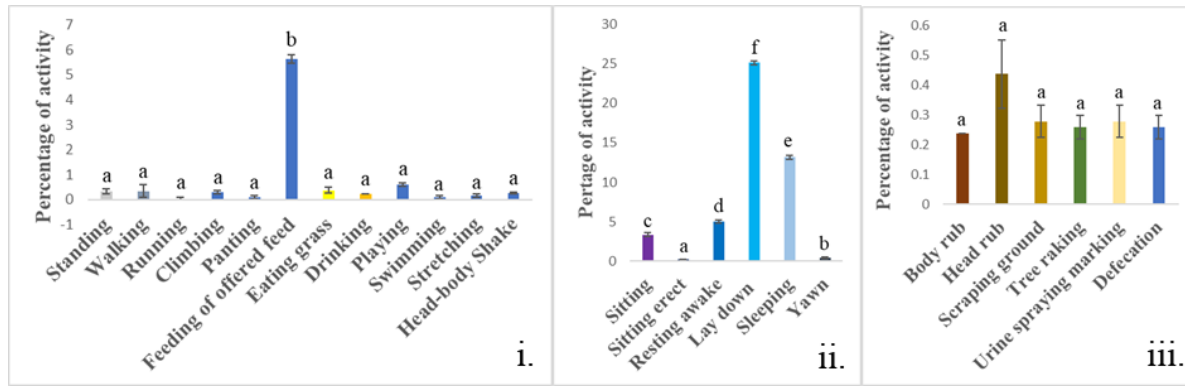


Fig. 4: Percentage of time spent in subcategories of active (i), resting (ii) and territorial (iii) behaviour by jaguar during winter season at Alipore Zoological Garden, Kolkata. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P < 0.05$) using DMRT after one-way ANOVA.

resting behaviours, the jaguar was found predominantly engaged in sleeping (17.76 ± 0.28) followed by lay down (12.24 ± 0.29), sitting (3.59 ± 0.26) ($P < 0.05$; DMRT). The lower mean value was found for sitting erect behaviour (0.22 ± 0.09). Among territorial activities, higher mean value was found for head rub (0.58 ± 0.14) followed by body rub (0.36 ± 0.07), urine spray marking (0.32 ± 0.07), tree raking (0.30 ± 0.09).

Diurnal activity budget of jaguar in different activities during winter season

During winter season, when the active behaviours of the jaguar were taken under consideration, it was observed that feeding of offered feed (5.63 ± 0.18) was significantly higher ($P < 0.05$; DMRT) and the time spent for the other activities like standing, walking, running, climbing, panting, eating grasses, drinking, playing, swimming, stretching, etc. did not show significant variations (DMRT) among them (Fig. 4). Running (0.04 ± 0.05) was found to occur with the lower mean value. Among resting activities, the jaguar dedicated most of its time in laying down (25.08 ± 0.21), followed by sleeping (13.13 ± 0.27), resting awake (5.00 ± 0.19), sitting (3.37 ± 0.22), yawning (0.44 ± 0.08), sitting erect (0.22 ± 0.04) ($P < 0.05$; DMRT). Under the territorial behaviours, time budgeting for the activities like body rub, head rub, scraping ground, tree raking, urine spray marking etc. did not vary significantly ($P < 0.05$;

DMRT). Whereas the higher and lower mean value was observed for head rub (0.44 ± 0.11) and body rub (0.24 ± 0), respectively.

Diurnal activity budget of jaguar in different activities during summer season

During the summer season, the jaguar allocated significantly more time to panting activity (6.88 ± 0.22) ($P < 0.05$; DMRT) of the active behavioural category (Fig. 5). Eating grasses was observed for lower mean value (0.04 ± 0.05) while, the values of walking, swimming, head-body shake did not vary significantly (DMRT). Among resting activities, sleeping was significantly higher (24.15 ± 0.28) whereas, sitting erect (0.22 ± 0.04) was lower ($P < 0.05$; DMRT). The jaguar devoted less amount diurnal time in the activities of the territorial category, those values did not show significant variations (DMRT).

Comparison of diurnal activity budget of the jaguar among three seasons

When the data of activity time budget of the jaguar were compared among three seasons (Fig. 6), it was observed that feeding of offered feed was significantly higher ($P < 0.05$; DMRT) in winter than the other two seasons, whereas, drinking did not show significant variation among the studied seasons (DMRT). Panting peaked in summer and significantly lower in winter season ($P < 0.05$; DMRT). Swimming was notably higher in summer whereas playing during the winter season. The

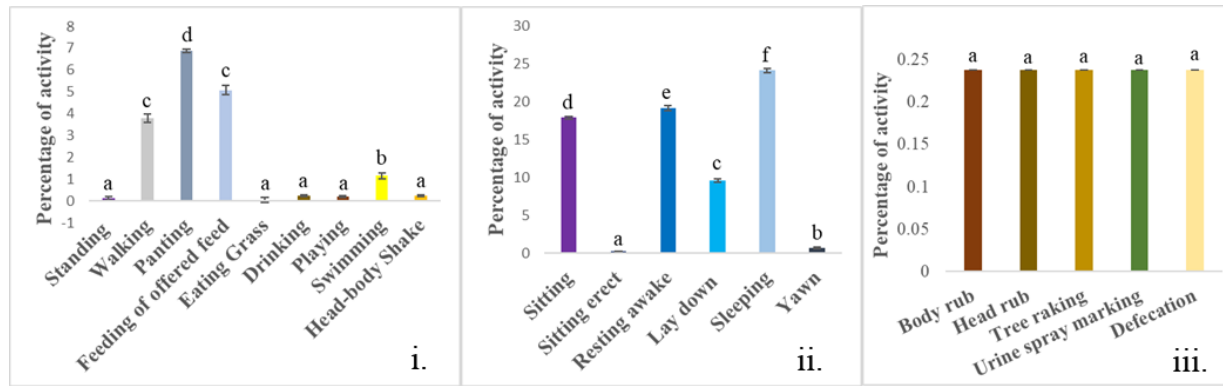


Fig. 5: Percentage of time spent in subcategories of active (i), resting (ii) and territorial (iii) behaviour by jaguar during summer season at Alipore Zoological Garden, Kolkata. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P < 0.05$) using DMRT after one-way ANOVA.

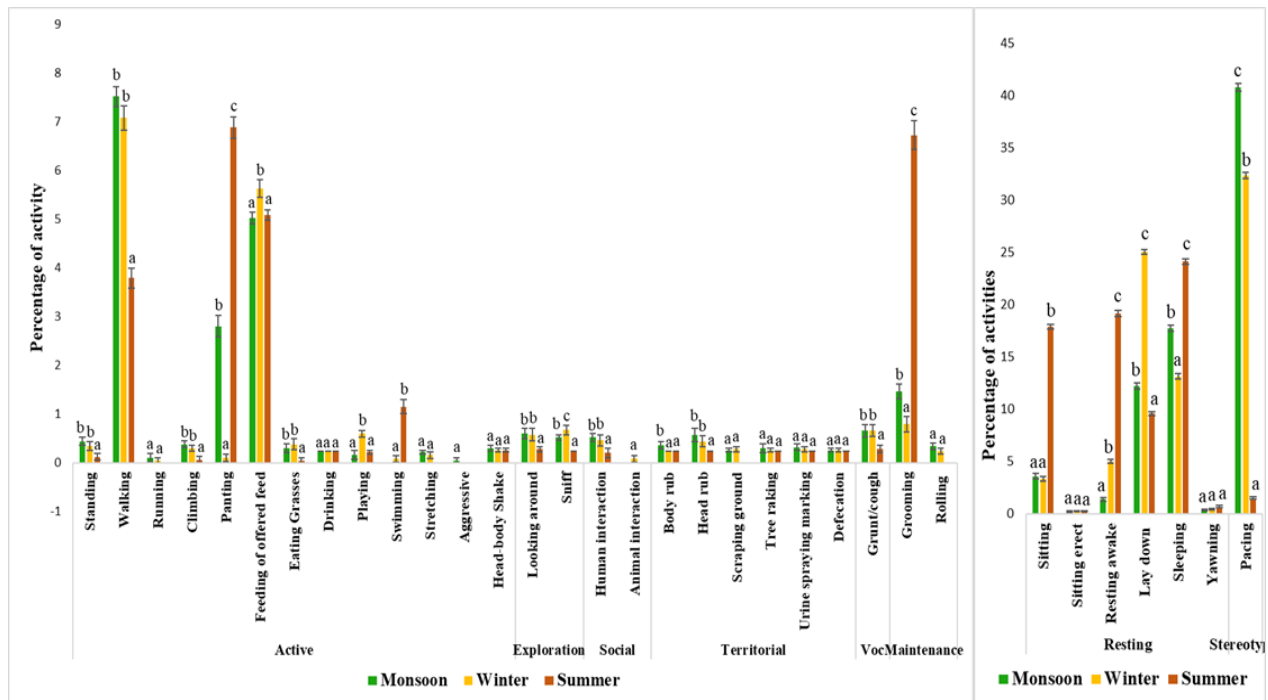


Fig. 6: Percentage of time spent in active, exploration, social, territorial, vocalization and maintenance behavioural categories by jaguar in three different seasons at Alipore Zoological Garden. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P < 0.05$) using DMRT after two-way ANOVA.

activities like standing, walking, climbing and eating grasses were found to occur in less frequency during the summer season ($P < 0.05$; DMRT). The Jaguar showed aggressive behaviour only in monsoon. Under the exploration category, significantly lower value for sniffing and looking around was observed in summer season, while higher sniffing was noted in winter season ($P < 0.05$; DMRT). Regarding its social activities,

animal interaction was only exhibited during winter, whereas human interaction was found lower during this season. When the territorial behaviours were considered, body rub was significantly higher in monsoon season ($P < 0.05$; DMRT), while the time spent for head rub did not vary between monsoon and winter (DMRT). No scraping ground activity was observed during summer. Other territorial behaviours showed no

significant variation among the three studied seasons. Under the vocalization category, grunt/cough was found lower in summer ($P < 0.05$; DMRT). Under maintenance behaviours, grooming was maximum in summer and minimum in winter ($P < 0.05$; DMRT). There was no rolling activity observed during summer season and the time spent for this activity by the studied jaguar did not vary significantly between the monsoon and winter season (DMRT). Among resting activities, significantly higher value of sitting, resting awake and sleeping was noted during summer season ($P < 0.05$; DMRT). On the contrary, laying down was significantly lower in summer ($P < 0.05$; DMRT). The jaguar spent less time in yawning and sitting erect activity during all the three seasons with insignificant variation. Stereotypic behaviour, pacing was observed at its peak during monsoon and at the lowest during summer season ($P < 0.05$; DMRT).

Hourly activity time budget of jaguar during monsoon season

Throughout the monsoon season, the jaguar exhibited a particular pattern of behaviours (Table 2). Among the active behaviours, feeding of offered feed was not observed during the whole day except for the last hour (16:00 h to 17:00 h) of observational period, whereas, activities like standing, climbing, playing and head-body shake reached peak from 10:00 h to 11:00 h, walking, running, panting and eating grasses from 11:00 h to 12:00 h and drinking, stretching and aggressive behaviour from 16:00 h to 17:00 h. Swimming was notably absent during this season. When the resting behaviours were considered, the higher mean value of sitting and yawning was noticed in the first hour (10:00 h to 11:00 h) of the observational study, laying down from 12:00 h to 13:00 h and, sitting erect and resting awake from 14:00 h to 15:00 h. The jaguar spent most of the time in sleeping from 11:00 h to 14:00 h, with the higher percentage in the fourth hour of observation. Both of the behaviours looking around and sniffing under the exploration category occurred at maximum frequency during

the first hour (10:00 h to 11:00 h) of observation. Social activities such as human interaction was noted to occur at higher rate from 10:00 h to 11:00 h while the jaguar showed no interaction with other animals in monsoon season. When territorial activities were considered, it was found that the studied animal exhibited maximum head rubbing in the first hour (10:00 h to 11:00 h) while, scraping ground and tree raking reached peak at the last hour (16:00 h to 17:00 h) of observation. Body rubbing and defecation had its peak value from 11:00 h to 12:00 h and 15:00 h to 16:00 h, respectively. Urine spray marking occurred at high rate in the second (11:00 h to 12:00 h) and second last hour (15:00 h to 16:00 h) of observation. The vocalization and maintenance behaviour occurred at higher frequency during the first hour (10:00 h to 11:00 h) except rolling which peaked at last hour (16:00 h to 17:00 h). The jaguar showed stereotypic behaviour pacing consistently through-out the day and was found to reach peak from 15:00 h to 16:00 h.

When data were compared within hours, among the active behaviours, it was observed that walking was the most time spent behaviour displayed by the animal except the last hour (16:00 to 17:00 h) in which feeding of offered feed had the highest value. After walking, panting was observed with higher rate in the first six hours. Under the resting behaviours, sleeping was found dominant for all the studied hours except the first (10:00 h to 11:00 h) and last hour (16:00 h to 17:00 h) in which lay down was highest. The second highest value was found for laying down from 11:00 h to 16:00 h and sitting during the final hour. Among exploration category, the jaguar dedicated most of the time in looking around except 10:00 h to 11:00 h. When territorial behaviours were considered, most of the time was spent in head rub except in the fifth hour and last hour of observation when the frequency of urine spraying and scraping ground was higher, respectively. Under maintenance activities, grooming was observed dominant all the time than the rolling activity.

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

Categories Behaviour	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
Active	Standing	1.11	0.56	0.28	0.14	0.28	0.14	0.28
	Walking	8.89	12.64	3.89	3.89	8.06	6.81	7.78
	Running	0.00	0.42	0.00	0.00	0.00	0.00	0.28
	Climbing	0.69	0.42	0.69	0.28	0.14	0.14	0.28
	Panting	2.22	4.44	2.08	2.50	2.08	1.94	4.31
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	35.14
	Eating grasses	0.28	0.83	0.14	0.14	0.14	0.28	0.14
	Drinking	0.28	0.28	0.00	0.00	0.14	0.28	0.69
	Playing	0.56	0.00	0.14	0.00	0.14	0.14	0.14
	Stretching	0.00	0.28	0.14	0.14	0.28	0.28	0.42
	Aggressive	0.00	0.00	0.00	0.00	0.00	0.00	0.28
	Head-body Shake	0.56	0.42	0.00	0.42	0.14	0.28	0.14
Resting	Sitting	5.28	3.47	2.92	1.53	3.75	4.31	3.06
	Sitting erect	0.14	0.14	0.28	0.14	0.56	0.14	0.14
	Resting awake	1.67	0.83	1.39	1.53	2.50	0.69	0.83
	Lay down	14.86	7.08	24.03	18.89	7.78	6.11	5.69
	Sleeping	9.03	23.89	33.75	37.50	17.22	8.47	2.50
	Yawning	1.39	0.28	0.14	0.00	0.14	0.28	0.14
Exploration	Looking around	1.67	0.83	0.42	0.14	0.69	0.14	0.14
	Sniffing	1.25	0.83	0.14	0.14	0.69	0.28	0.14
Social	Human interaction	1.39	0.42	1.25	0.14	0.28	0.14	0.00
Territorial	Body rub	0.42	0.56	0.42	0.14	0.28	0.28	0.42
	Head rub	1.53	0.69	0.42	0.42	0.28	0.69	0.00
	Scraping ground	0.00	0.14	0.28	0.14	0.28	0.28	0.69
	Tree raking	0.28	0.42	0.28	0.28	0.28	0.00	0.56
	Urine spray marking	0.28	0.56	0.14	0.14	0.42	0.56	0.14
	Defecation	0.42	0.42	0.00	0.00	0.28	0.56	0.14
Vocalization	Grunt/cough	1.25	1.11	0.28	0.69	0.42	0.28	0.28
Maintenance	Grooming	3.47	0.97	1.39	1.53	0.56	0.69	0.97
	Rolling	0.42	0.28	0.42	0.14	0.28	0.14	0.69
Stereotype	Pacing	40.69	36.81	24.72	29.03	51.81	65.69	33.61

Hourly activity time budget of jaguar during winter season

The hourly activity budget of winter season (Table 3) revealed that among the active behaviours, feeding of offered feed was observed only during

the last hour (16:00 h to 17:00 h) of observation period. Behaviours like standing, climbing and eating grasses were noted to be higher in the first hour (10:00 h to 11:00 h). On the other hand, walking, stretching and head-body shake peaked

Table 3: Mean hourly activity pattern of jaguar from 10:00 h to 17:00 h during winter season at Alipore Zoological Garden, Kolkata

Categories Behaviour	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
Active	Standing	0.69	0.28	0.14	0.00	0.14	0.56	0.56
	Walking	9.58	2.78	2.64	1.11	7.08	14.86	11.53
	Running	0.00	0.00	0.00	0.00	0.14	0.00	0.14
	Climbing	1.25	0.28	0.14	0.00	0.00	0.42	0.00
	Panting	0.14	0.00	0.28	0.00	0.00	0.28	0.00
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	39.44
	Eating grasses	0.97	0.00	0.00	0.42	0.14	0.69	0.42
	Drinking	0.00	0.00	0.00	0.00	0.00	0.14	1.53
	Playing	0.14	0.28	0.56	0.00	0.56	1.25	1.39
	Swimming	0.00	0.00	0.00	0.14	0.14	0.14	0.14
	Stretching	0.00	0.00	0.14	0.00	0.28	0.42	0.28
	Head-body Shake	0.28	0.14	0.00	0.00	0.14	0.83	0.42
Resting	Sitting	10.28	1.39	4.72	2.64	1.39	1.25	1.94
	Sitting erect	0.14	0.14	0.14	0.14	0.00	0.28	0.69
	Resting awake	7.08	7.92	4.44	5.97	5.56	3.61	0.42
	Lay down	30.14	26.11	34.03	47.64	20.56	13.89	3.19
	Sleeping	0.56	50.14	28.33	12.22	0.69	0.00	0.00
	Yawning	0.56	0.28	0.28	0.14	0.42	1.25	0.14
Exploration	Looking around	1.94	0.00	0.14	0.14	0.28	1.39	0.14
	Sniffing	2.36	0.28	0.28	0.14	0.83	0.83	0.00
Social	Human interaction	0.56	0.42	0.00	0.00	0.83	1.39	0.00
	Animal interaction	0.00	0.00	0.00	0.00	0.00	0.28	0.28
Territorial	Body rub	0.14	0.00	0.00	0.00	0.28	0.56	0.69
	Head rub	0.42	0.00	0.00	0.14	1.11	1.25	0.14
	Scraping ground	0.00	0.28	0.00	0.00	0.00	1.25	0.42
	Tree raking	0.28	0.00	0.14	0.14	0.42	0.69	0.14
	Urine spray marking	0.14	0.14	0.00	0.00	0.28	0.97	0.42
	Defecation	0.14	0.00	0.14	0.14	0.28	0.56	0.56
Vocalization	Grunt/cough	0.69	0.69	0.14	0.00	0.42	2.22	0.42
Maintenance	Grooming	0.97	0.14	0.69	0.14	1.25	1.39	0.97
	Rolling	0.14	0.00	0.00	0.14	0.00	0.83	0.56
Stereotype	Pacing	30.42	8.33	22.64	28.61	56.81	46.53	33.06

from 15:00 h to 16:00 h and drinking and playing was observed with higher frequency from 16:00 h to 17:00 h. Running was only observed in the fifth hour (14:00 h to 15:00 h) and the last hour (16:00 to 17:00 h) whereas, panting occurred in the third

(12:00 h to 13:00 h) and sixth hour (15:00 h to 16:00 h) of the observation period. The jaguar displayed swimming in the last four hours only (13:00 h to 17:00 h) and he did not show aggression during this season. When considering

the resting activities, sitting was noticed to be higher in the first hour (10:00 h to 11:00 h) and sitting erect in the last hour (16:00 h to 17:00 h). Behaviours such as laying down and yawning were found to reach the peak value from 13:00 h to 14:00 h and 15:00 h to 16:00 h, respectively. Other resting behaviours like resting awake and sleeping occurred at higher frequency during the second hour (11:00 h to 12:00 h) of the observation. Both of the behaviours, looking around and sniffing under the exploration category reached peak from 10:00 h to 11:00 h. Among social behaviours, the studied animal was found to interact with other animals only in the last two hours (15:00 h to 17:00 h), while the human interaction was more in the sixth hour (15:00 h to 16:00 h) of the observation. Under territorial behaviours, all of the activities were found to occur at maximum rate from 15:00 h to 16:00 h except body rub which peaked during last hour (16:00 h to 17:00 h) of observation. Vocalization and maintenance behaviour occurred at high rate in the second last hour (15:00 h to 16:00 h) of observation. The jaguar spent most of its time in stereotypic activity, pacing in the fifth hour (14:00 h to 15:00 h) of the studied period.

During the winter season, within active behaviours, walking had the highest mean value in the first hour (10:00 h to 11:00 h), followed by climbing, eating grasses. Walking was dominant activity throughout the day except the last hour (16:00 h to 17:00 h) of observational period when the jaguar spent most of the time in feeding offered feed followed by walking. Within resting category, sleeping was found dominant in the second hour of observation period (11:00 h to 12:00 h), whereas lay down remained dominant during the rest of the observation hours. Among exploration category, between looking around and sniffing, sniffing was noticed to occur at higher rate during the first five hours (10:00 h to 15:00 h) while, looking around during the last two hours. Within social behavioural category, it was noted that human interaction was more than the animal interaction throughout the day except last hour of observation when jaguar involved in animal

interaction. When the territorial activities were considered, head rub dominated over tree raking in the first hour (10:00 h to 11:00 h) and the fifth hour (14:00 h to 15:00 h). From 11:00 h to 12:00 h, scraping ground was more frequent activity while from 12:00 h to 13:00 h, only tree raking and defecation were noted to occur at same frequency and from 13:00 h to 14:00 h the observed activities were head rub, tree raking and defecation, occur at same rate. Within maintenance behavioural category, grooming was noted with higher rate than rolling for the whole day.

Hourly activity time budget of jaguar during summer season

During summer season (Table 4), under the active behaviours, feeding of offered feed was only observed from 16:00 h to 17:00 h. Panting and walking reached the peak from 10:00 h to 11:00 h and 15:00 h to 16:00 h. Climbing was noted in the first two hours of observation, while eating grasses and drinking in the last hour of observation. The jaguar engaged in the playing and swimming activity in the last three hours where the peak value was recoded from 16:00 h to 17:00 h. During summer, the jaguar did not exhibit any running, stretching and aggression. Among resting activities, sitting and yawning occur at high frequency from 10:00 h to 11:00 h. Resting awake and laying down was observed to happen at higher rate in the second hour (11:00 h to 12:00 h) of observation. The studied animal spent more time in sleeping from 13:00 h to 14:00 h. Among exploration behaviours, looking around and sniffing occur at high frequency in the first (10:00 h to 11:00 h) and sixth hour (15:00 h to 16:00 h), respectively. The jaguar displayed social behaviour, human interaction mostly in the first hour (10:00 h to 11:00 h) of observation. When territorial activities were considered, body rub, head rub and tree raking were found to occur from 15:00 h to 17:00 h, while the frequency of urine spray marking and defecation was more at 10:00 h to 11:00 h and 15:00 h to 16:00 h, respectively. Under vocalization category, grunting/coughing and under maintenance category, grooming

Table 4: Mean hourly activity pattern of jaguar from 10:00 h to 17:00 h during summer season at Alipore Zoological Garden, Kolkata

Categories Behaviour	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
Active	Standing	0.28	0.00	0.00	0.00	0.00	0.56	0.00
	Walking	4.03	1.94	1.81	0.56	2.64	8.19	7.36
	Running	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Climbing	0.28	0.14	0.00	0.00	0.00	0.00	0.00
	Panting	14.86	6.81	5.69	1.67	6.25	6.81	6.11
	Feeding of offered feed	0.00	0.00	0.00	0.00	0.00	0.00	35.56
	Eating grasses	0.00	0.00	0.00	0.00	0.00	0.14	0.14
	Drinking	0.00	0.00	0.00	0.00	0.00	0.28	1.39
	Playing	0.00	0.00	0.00	0.00	0.28	0.42	0.83
	Swimming	0.00	0.00	0.00	0.00	1.53	2.50	4.03
	Head-body Shake	0.28	0.28	0.00	0.00	0.28	0.42	0.56
Resting	Sitting	39.17	13.75	8.06	4.72	16.94	26.25	16.39
	Sitting erect	0.28	0.14	0.00	0.00	0.42	0.28	0.42
	Resting awake	19.86	49.44	18.33	10.97	19.72	12.08	3.89
	Lay down	5.83	14.44	12.92	11.67	12.78	7.36	2.22
	Sleeping	0.00	7.92	48.19	64.72	31.94	16.25	0.00
	Yawning	1.81	0.28	0.14	0.42	0.56	1.11	0.56
Exploration	Looking around	1.25	0.14	0.00	0.00	0.14	0.28	0.14
	Sniffing	0.00	0.00	0.00	0.14	0.14	0.97	0.42
Social	Human interaction	0.56	0.00	0.14	0.00	0.00	0.42	0.28
Territorial	Body rub	0.00	0.00	0.00	0.00	0.00	0.83	0.83
	Head rub	0.00	0.00	0.00	0.00	0.00	0.83	0.83
	Tree raking	0.00	0.00	0.00	0.00	0.00	0.69	0.97
	Urine spray marking	0.83	0.14	0.00	0.00	0.00	0.00	0.69
	Defecation	0.14	0.00	0.00	0.00	0.28	0.69	0.56
Vocalization	Grunt/cough	0.28	0.14	0.00	0.14	0.00	1.11	0.28
Maintenance	Grooming	9.03	3.61	3.89	4.58	6.11	8.75	11.11
Stereotype	Pacing	1.25	0.83	0.83	0.42	0.00	2.78	4.44

reached peak from 15:00 h to 16:00 h and 16:00 h to 17:00 h, respectively. Stereotypic activity, pacing was observed at the highest frequency from 16:00 h to 17:00 h.

When activity budgets were compared among the different observational hours, it was noticed that under active behavioural category, panting was the predominant activity for all of the hours

except the last two hours, walking in second last hour and feeding of offered feed in last hour. The second highest value was observed for walking except from 15:00 to 16:00 h when panting had higher mean value. Among resting behavioural category, sitting dominated the first (10:00 h to 11:00 h), sixth (15:00 to 16:00 h) and last hour (16:00 to 17:00 h) followed by resting awake,

sleeping and resting awake, respectively. In the second hour of observation, resting awake occur at high rate, followed by lying down, sitting and sleeping. Sleeping was the most frequent behaviour consecutively for three hours (12:00 to 15:00 h). Within territorial behavioural category, in the first hour, only urine spray marking and defecation were observed, where urine spray marking with higher rate. For the second to fifth hours no territorial activities were recorded, except in the third and fifth hour when only urine spray marking and defecation was observed, respectively. In the last hour of observation period, tree raking was noted with higher rate.

Comparison of activity budget among seasons in different hours

From 10:00 h to 11:00 h:

When data were compared among the season, in the first hour of observational period, it was observed that within in active behavioural category, panting (14.86%) was higher in summer followed by monsoon, winter season (Fig. 7). On the other hand, walking (9.58%) was most prevalent during the winter compared to monsoon and summer. Climbing was observed in higher rate during winter than monsoon and summer. Resting activities such as sitting (39.17%) and resting awake (19.86%) was notably higher during summer compared to other studied seasons, whereas lay down (30.14%) was observed more in winter. Within maintenance behavioural category, grooming (9.03%) occurred at higher rate in summer, while rolling (0.42%) occurred more in monsoon than the other two seasons. Stereotypic behaviour, pacing (40.69%) was found more during monsoon followed by winter, summer.

From 11:00 h to 12:00 h:

When comparing the mean percentage of time spent in different activities among the three seasons, in the second hour of observation, it was recorded that jaguar spent most of its time in walking (12.64%) and panting (6.81%) during monsoon and summer, respectively (Fig. 7). Active

behaviours like climbing and head-body shake was noted to occur at higher rate in monsoon. When resting activities were considered, sitting (13.75%) and resting awake (49.44%) was dominant during summer, while sleeping (50.14%) was found higher in winter. Grooming was observed more in summer. Stereotypic behaviour, pacing (36.81%) was dominant during monsoon, followed by winter, summer.

From 12:00 h to 13:00 h:

During the third hour of observation, in case of resting behavioural category, the plotted graph (Fig 7) revealed that the highest time spent in panting (5.69%) occurred in summer whereas, for walking (3.89%), it happened in monsoon. Sitting (8.06%), resting awake (18.33%) and sleeping (48.19%) was noticed with higher frequency during summer and lay down (34.03%) during winter. Among maintenance behaviours, grooming (3.89%) was dominant in summer compared to other seasons. Pacing (24.72%) was more frequent in monsoon followed by winter, summer.

From 13:00 h to 14:00 h:

When comparing the data across seasons, in the fourth hour of observation, it was noticed that among active behaviours, the mean-time percentage for the walking (3.89%) and panting (2.5%) was higher during monsoon compared to other seasons (Fig. 7). The jaguar was predominantly engaged in sitting (4.72%) and sleeping (64.72%) in summer and lay down (47.64%) during winter than other seasons. Grooming (4.58%), under maintenance category, was higher in summer, whereas the stereotypic behaviour, pacing (29.03%) was dominant during monsoon.

From 14:00 h to 15:00 h:

During the fifth hour of the observational study, walking (8.06%) and panting (6.25%) under active behavioural category, was noted to occur at the highest frequency in monsoon and summer, respectively (Fig. 7). Sitting (16.94%), resting awake (19.72%) and sleeping (31.94%) were the most frequent behaviour in summer. On the other

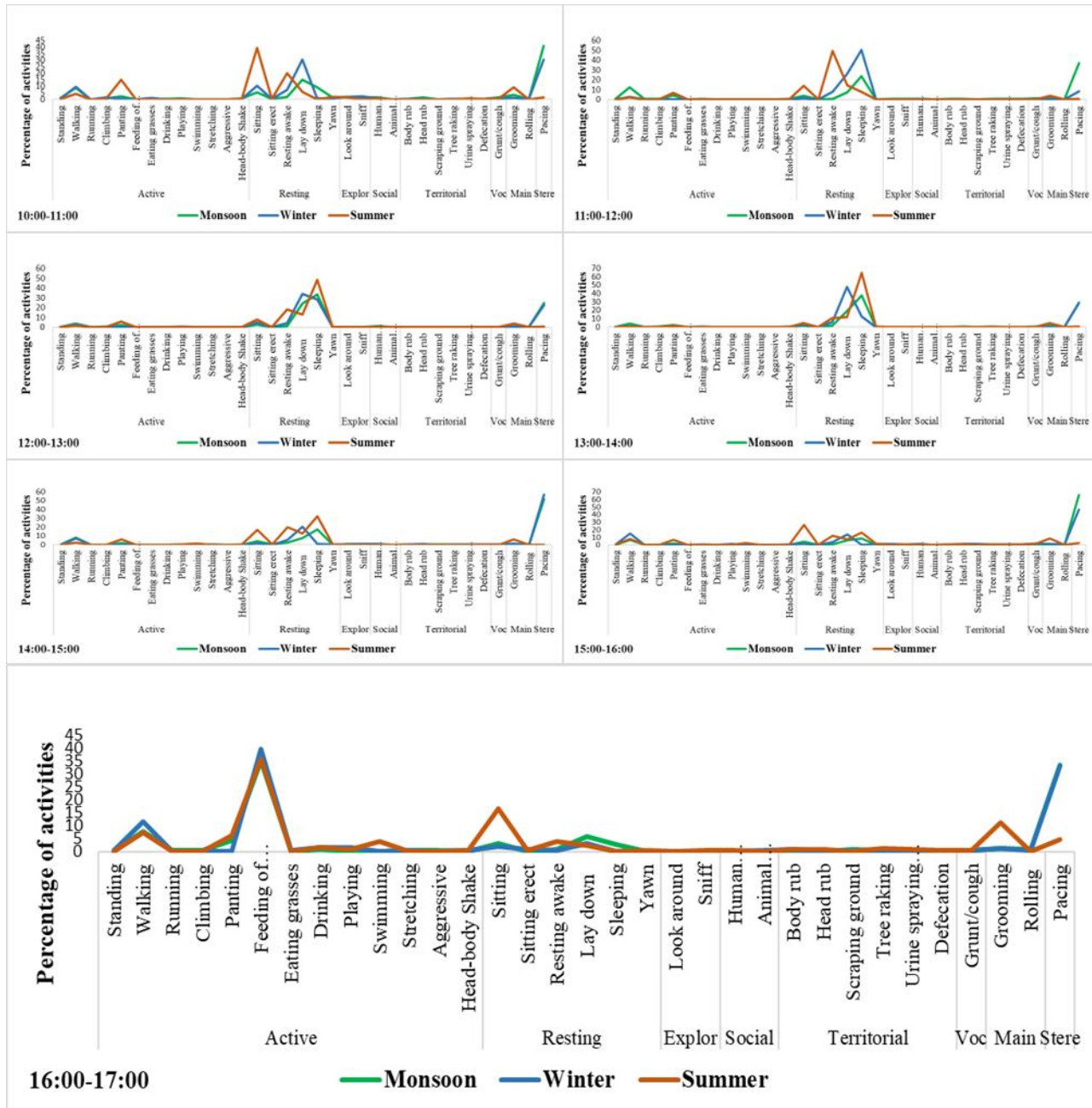


Fig. 7: Activity budget of jaguar in different seasons from 10:00 h to 17:00 h in Alipore Zoological Garden, Kolkata.

hand, the animal predominantly exhibited laying down (20.56%) in winter than the monsoon and summer seasons. Among maintenance activities, grooming (6.11%) was noticed to have higher frequency in summer. In case of pacing, it had the highest value (56.81%) in winter than monsoon.

From 15:00 h to 16:00 h:

When the mean time spent percentage of the

jaguar was compared among three seasons, from 15:00 h to 16:00 h, it was observed that walking (14.86%) was more during winter followed by summer, monsoon and panting (6.81%) peaked during summer (Fig. 7). Active behaviours such as swimming (2.5%) was dominant during summer. Under the resting activities, sitting (26.25%), resting awake (12.08%) and sleeping (16.25%) showed considerably higher value in summer

while, lay down (13.89%) was noted more in winter. Among maintenance activities, the animal groomed (8.75%) itself by taking more time in summer. Stereotypic activity, pacing (65.69%) was observed to occur at high rate during monsoon, followed by winter, summer.

From 16:00 h to 17:00 h:

When active behaviours of the final hour were analysed, it was observed that among the three studied seasons, the jaguar spent more time in swimming (4.03%) and panting (6.11%) during summer while in walking (11.53%) and standing (0.56%) during winter (Fig. 7). Running (0.28%) peaked in monsoon and was absent in summer. The animal spent its maximum time in feeding of offered feed (35.14%-39.44%) in all the three seasons with slightly more in winter. Among the resting activities, sitting (16.39%) and resting awake (3.89%) reached peak in summer while lay down (5.69%) occurred more in monsoon. Grooming (11.11%) reached highest mean value in summer whereas, stereotypic behaviour, pacing (33.61%) was noted more in monsoon.

Discussion

Behavioural studies are the key aspects for conservation from which we come to know about the animal's adaptation in its captive environment as well as its response to stress. The present study aims to determine a daytime activity time budget of a male captive jaguar to assess its current condition and to develop best practice management. In wild, male jaguars were found active 57% of the time (Rabinowitz and Nottingham, 1985). On the contrary the studied jaguar was observed to be spending more time in resting behaviours which could be due to its captive environment.

The studied jaguar was engaged in feeding of offered feed in the final hour (16:00 h to 17:00 h) of the observational period, through-out all the three seasons as the zoo authority provided the feed after 4:30 pm. Feeding activity was found slightly higher in winter which could be due to the increased energy demand during low temperature to maintain the internal temperature of its body.

Swimming was notably higher in summer which might be due to scorching heat of summer and their water loving characteristics. Panting was found at high rate in summer probably because of the high temperature of this season and they engaged in panting to reduce its body temperature by evaporation. This animal, being an excellent climber, climbed the trees of enclosure more during monsoon. The reason behind this could be for resting, as the tree is a safe and comfortable place to relax. The study revealed that no running was noticed during summer which could be due to the high temperature. In a study (Knight, 2016) on captive jaguars, the male one exhibited the highest amount of active walking behaviour between 12:00 h to 15:00 h whereas, the present study showed that the male jaguar reached peak value of walking from 11:00 h to 12:00 h (in monsoon). According to a study by Rabinowitz and Nottingham (1985), wild jaguars in Belize predominantly exhibited the travelling activity during the early evening. Here, in captivity too, the jaguar became more active during twilight which supports the fact of being 'crepuscular'. In the present study, it was found that the captive jaguar marked its territory by urine spraying, tree raking, ground scraping, body rubbing, head rubbing and defecating just like the ones in wild, which is similar to studies by Rabinowitz and Nottingham (1985). Higher values of tree raking, and head and body rubbing were noted in monsoon particularly after a fresh shower which might be to keep the markings those were washed away. The jaguar usually urinated at a low rate (once or two times a day) probably because of its less drinking behaviour (once a day). Under maintenance behaviours, grooming was dominant during summer compared to other seasons. Over grooming could be a sign of stress and it can grow as a coping mechanism for relaxation or to deal with anxiety (Morris, 2018). The jaguar spent most of its time sitting, resting awake and sleeping under the tree in summer to protect itself from the scorching heat of the sun. In case of wild jaguars, their resting activities reached highest level during midday (12:30 h to 15:30 h) (Rabinowitz

and Nottingham, 1985) which is similar to the findings of this study of the captive jaguar. In its case, sleeping level remained high in summer from 12:00 h to 3:00 h.

Observing animal behaviours is a current interest of wildlife researches as it plays a vital role in measuring the welfare of the animal. There is a chance of negative impact of captivity on zoo animals due to the less variable environment than the wild and sometimes they display different behaviours besides their normal activities. The findings of the present study indicates that the zoo-housing facilities might be not appropriate for the studied animal as the jaguar was engaged in stereotypic behaviour, pacing for a large span of time of its daily activity pattern. The studied jaguar exhibited pacing mostly during monsoon (65.69%) which supported the earlier survey results (Morris, 2018) that revealed pacing was the most common stereotypic behaviour found among zoo-housed jaguars (67%) during the monsoon season. Stereotypic behaviours are thought to develop as a result of many factors such as attempts to display a behaviour which the animal is unable to show in captivity (Hinde, 1970; Mason, 1991) or inability to escape from an unpleasant stimulus (Duncan and Wood-Gush, 1972; Hinde, 1962; Mason, 1991b). In this study it was noted that this stereotypic pacing was more frequent in the late afternoon (14:00 h to 17:00 h) which probably implies its anticipation of time of feed offering. Though further investigation is necessary to confirm the relationship between the pacing times of day and the rate of pacing. In wild, jaguars hunt their prey, protect their territories and reproduce. While in captivity, they do not have those opportunities or need to fulfil those tasks. As a result, they easily became depressed and distressed and due to their high level of anxiety they display stereotypic behaviours like pacing. Hence, it can be depicted that pacing can rise as a form of frustration and is associated with poor welfare.

Conclusion

The studied male jaguar displayed a behavioural

pattern not only in all the three seasons, but also in the different hours of the observational period. Among different activities, the jaguar remained engaged mostly in resting behaviour during summer and winter whereas, it displayed stereotypic pacing at high frequency in monsoon. The findings of the present study on diurnal activity time budget of captive male jaguar can aid in differentiating the behavioural patterns between the wild and the captive ones. Therefore, the present study might be useful for taking the strategies to overcome the captive environmental challenges and to improve the management of captive jaguar, which will ensure their healthy life in captivity.

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Conflict of Interest

The authors declare no conflicts of interest.

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