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Diurnal Behavioural Patterns and Activity Budget of Great Indian One-Horned Rhino (*Rhinoceros unicornis*) in Alipore Zoological Garden, Kolkata, India

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Abstract: Diurnal behavioural study of Great Indian one-horned rhino (*Rhinoceros unicornis*) was conducted from August 2022 to June 2023 in Alipore Zoological Garden, Kolkata, India, in order to determine the overall behavioural patterns with the variations in seasons and hourly activity budget from 10.00 to 17.00 hours by using the methodology of focal sampling with 23,520 min of observations. Study revealed that rhino showed significant variations in activities among seasons and in the different hours within a day. Rhino spent maximum time in feeding activity, followed by comfort behaviour during winter, whereas during monsoon and summer they displayed maximum comfort behaviour, followed by the feeding activity. Under comfort behaviour, resting was more in summer, followed by monsoon and then in winter. Locomotion was found more in winter, followed by monsoon and then in summer. Wallowing was maximum during summer, followed by monsoon and winter. A higher percentage of vigilance activity was found during monsoon, followed by summer and then in winter. Feeding was higher in two times, at 10.00-11.00 hours during entire the study period and at 13.00-16.00 hours during monsoon and winter, and at 16.00-17.00 hours during summer. In all the seasons, locomotion was found more at 10.00-11.00 hours and also found in higher proportion at 13.00-15.00 hours during monsoon, at 12.00-14.00 hours and 15.00-16.00 hours during winter. Water wallowing showed peak at 15.00-16.00 hours during monsoon, 13.00-14.00 hours during winter and 14.00-16.00 hours during summer. This study would be useful in determining the changes in the behavioural patterns of rhino inside the enclosure.

Keywords: Activity budget, Behavioural patterns, Focal sampling, *Rhinoceros unicornis*, Wallowing

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Introduction

Behaviour is any action displayed by an animal, could be the response to a stimulus, which might be intrinsic or extrinsic, or the way of interaction

with all the organisms and the physical environment. Certain intrinsic stimuli are the craving, anxiety etc., and extrinsic stimuli are the

resources, competitors, environmental factors and the habitat availability (Gaulin, 1979; Zielinski *et al.*, 1983). Behaviour exhibits how animals associate to their surroundings and to other living creatures, how animals discover and protect resources, keep away from predators, select mate, reproduce etc. Whereas, the study of ethology describes how physiology and anatomy of an animal, are combined with its behavior. Behavioural pattern of an animal is not only species specific but also show a significant amount of variation among the individuals or groups, belonging to a same species. These might be due to the variations of responses. Responses of an animal generally are varied with the habitat conditions (e.g., availability of food), environmental factors (climatic factors like temperature, rainfall etc.) and the social factors (Hazarika and Saikia, 2010).

The success of wildlife conservation, management and captive breeding of a wildlife species depends on various components. Among them a better understanding of their characteristics, behavioural pattern and also the time budgeting of the activity catalogue are considered as the most crucial ones which play the key role for developing their conservation strategies and also provide more informed decision for their management (Hutchins and Kreger, 2006) and well-being. The Indian rhinoceros or Great Indian one-horned Rhinoceros, belonging to the Rhinocerotidae family (*Rhinoceros unicornis*), is listed as vulnerable in the IUCN Red List of Threatened species. They are the endemic species of the northeast region of India but now were confined to few pockets of the north-eastern part of India and Nepal (Owen-Smith, 1988). Their number is decreasing day by day and survival is threatened due to habitat fragmentation, habitat loss, illegal trade, poaching, and human-rhino conflict (Medhi and Saikia, 2020). They are considered as keystone species due to their contribution in the health of environment. Thereby, implementation of different coordinated conservation initiatives is

needed to revive their population and to pull them back from verge of extinction.

Indian rhinos are solitary as well as ancient herbivorous mammal, looked unique due to its bizarre build, long boat-shaped head, its thick-skinned folds of shield and tuberculated hide (Sinha *et al.*, 2011). Being a fourth largest terrestrial animal, the weighs of male averages about 2260 kg to 3000 kg whereas the female weighs about 1600 kg. They might be 1.7 to 2 m tall and about 4 m long (Das, 2019). They have a grey brown skin with heavy folds on before and behind the shoulder and in front of thighs, which act as body shield (Sinha *et al.*, 2011). They have wart like bumps on their flanks, hind legs and shoulders. On snout, they have single horn of about 20 cm to 57 cm in length, used infrequently for defense mechanism and mostly for foraging to uproot the plants (Das, 2019). According to the report of the International Rhino Foundation (IRF, 2022), rhino population has increased from about 2050 individuals in 2008 to 4014 individuals in 2022 in India. The increase in number of rhinos is mainly due to continuous conservation efforts and taking various strategies and their implementation. For making the successful conservation strategies, there is a need of knowledge about their behavioral patterns; thereby simple observation based long-term behavioural studies are likely to be very important for both the *ex situ* and *in situ* conservation and, their translocation and management. Due to the lacunae of knowledge regarding behavioral patterns, there remains some behavioral issues, results difficulties in conservation and captive breeding (Deka and Sarma, 2015).

Few scattered information regarding the daily activity pattern of rhino is available, which were conducted either in sanctuary or in national parks (Hazarika and Saikia, 2010; Deka *et al.*, 2013; Medhi and Saikia, 2020; Dutta *et al.*, 2021). Study on captive rhino has not been done so far in India, which is important for their management in zoo and also for captive breeding.

Reports on the behavioral pattern of rhino are nearly 40-year's back (Ripley, 1952; Kakoti and Rajkonwar, 1972; Laurie, 1978; Bhattacharya and Pal, 1982). Globally, the weather, environment and their habitat quite changed due to global warming. Considering the scarcity of detailed information on the behavioral pattern of captive rhino from a long-period study, eleven-months observational study was attempted to fulfill the knowledge gap and to provide information on diurnal activity pattern and time budget analysis of rhino, *R. unicornis*, in captive condition at Zoological Garden, Kolkata, India.

Materials and Methods

Study Site:

The present study on behavioural pattern of Great Indian one-horned rhino was carried out at Alipore Zoological Garden (22°32'9.29" N, 88°19'55.39" E), Kolkata, West Bengal. It is one of the oldest zoological parks of India as well as the busiest tourist attraction point. The zoo was inaugurated as Alipore Zoo on 1st January 1876. It covers about 18.811 ha area. Varieties of animals belonging to nearly all the vertebrate groups are housed here. In Alipore Zoo, approximately 1300 animals are present. The zoo has ecological significance as it is a home for many wintering migratory birds. Loamy alluvial soil is noted here. Moderate type of climatic condition is found here. The summer season which begins in March and ends with the start of rainy season. Maximum temperature of summer shoots up to 42°C with an average of 35°C. Winter season begins with the end of rainy season and continue till the February. The lowest temperature during winter season is 8°C with an average of 13°C. Monsoon starts in the July and ends in the month of September. The yearly rainfall of Kolkata is about 1641.4 mm.

Studied Animal and Enclosure of the Animal:

The studied animal is a male Great Indian one-horned rhinoceros (*R. unicornis*), named by zoo authority as Jaldaprasad. He was adopted by Indian Oil Corporation Limited Haldia Refinery. He

is around 8 years old. His diet basically contains green grasses, leaves, wheat bran, crushed oats, crushed barley, soaked gram, sweet potatoes, carrots, bananas, beans, molasses, boiled pulses, leafy vegetables, sugarcane top soaked corns, etc. The food is provided twice in a day (before 09:30 am and after 04:30 pm) in the food container. Rest of the time rhino forages for grasses, leaves, etc.

The study animal, Indian one-horned rhinoceros was kept in an open-air moated enclosure which is situated in the west side of Alipore zoo. The enclosure is about 2011.07 sq.m. In the middle of the enclosure, there are two large trees (Fig. 1). The entire enclosure has grass covering. Three sides of the enclosure were surrounded by a narrow water canal. From outside to inside, the enclosure is guarded by the steel-made railing, followed by a layer of small trees, iron-made chain-link fence with barbed wire on top and then by a cemented wall (~1.5 m height). On the south-east corner of the enclosure, there is a shelter having a feed container where feed mixture is given. Beside the shelter, there is another cemented feed container for giving grasses. Visitors can see the Indian one-horned rhino from the north and east sides of the enclosure.

Data collection:

A study on activity pattern of Indian one-horned rhinoceros was carried out for eleven-months in the Alipore Zoological Garden from monsoon to summer seasons (two and half months from Monsoon, four and half months from Winter and four months from Summer). Focal sampling method was used which was adopted from Altmann (1974). The behavioral patterns were recorded and marked on a sheet between 10 am to 5 pm twice in a week through simple observation with unaided eye. All the activities were recorded in each minute with a gap of 1 minute in every 5 minutes from a suitable point from where the enclosure can be best seen without creating any disturbances to the animal or environment. Total observations were carried out for 23,520 minutes.

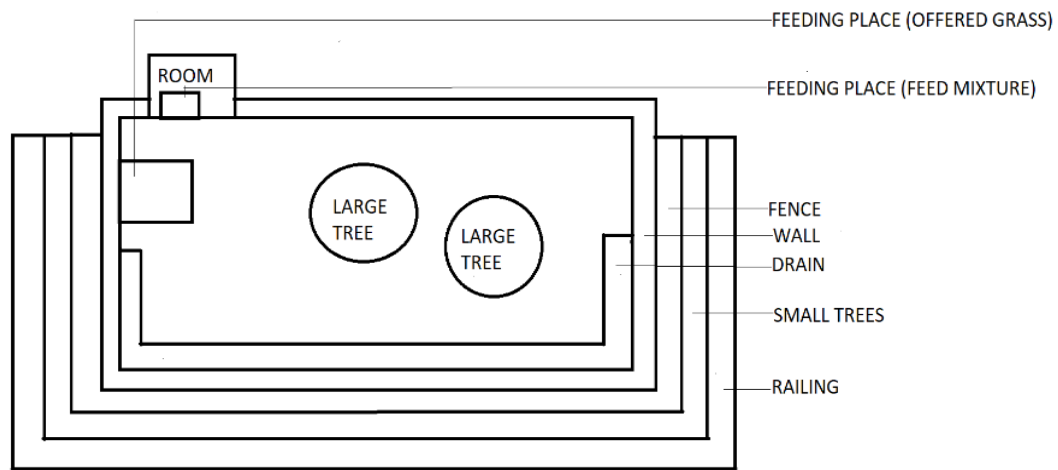


Fig. 1: Layout of Indian one-horned rhinoceros enclosure at Zoological Garden, Alipore (based on visual observations during present study).

Ethogram:

An ethogram is a list of behaviors displayed by the study animal and it could be depicted as a complete catalogue of the behavioral patterns of the studied animal. An animal's behavioural pattern is naturally occurring, a continuous flow of events. Assembling the continuous event into categories would be useful for the researchers to make distinctions among the displayed behaviours and measurements of a particular behaviour performed by that animal. At the time of preparing an ethogram, proper denoting of each behavior with a definite description is essential. On the basis of previous behavioural reports on Rhino (Hazarika and Saikia, 2010; Medhi and Saikia, 2020) and of the current preliminary observations, an ethogram was prepared for the behavioral study on rhino (Table 1). A total of 10 major behavioural patterns were categorized for the rhino in Alipore Zoological Garden. These were feeding, locomotion, comfort behaviour, standing, playing, vigilance, vocalization, defecation, urination and self-maintenance. Then some major types were categorized into subtypes, such as under feeding seven subtypes were identified, those were grazing, browsing, dive feeding, geophagy, feeding of offered grasses, feeding of offered feed mixture and drinking. Under locomotion, two subtypes were easy walking and running. Under comfort behaviour, five subtypes

were resting inside and outside the shed, sleeping inside and outside the shed and water wallowing. Under the standing activity, two subtypes were standing inside and outside the shed.

The time budgeting of different activities displayed by the studied rhino in a specified time span provides an opportunity for making comparisons between the behaviours expressed by wild and captive rhino, pointing out the differences observed and then finding out the causes of such differences.

Data Analysis:

Behaviours were measured by counting the number of events (frequency). All the graphical representations were prepared by using MS-Excel software. The percentage of time spent in the displayed activities were calculated by using formula given by Crockett and Ha (2010). Total time spent in a particular activity (focal-animal sampling) = (total time spent in a particular activity during observation / total duration of observation) $\times$ 100. The experimental data were presented as mean $\pm$ standard error (SE). 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 to compare the differences in activity patterns for hourly and seasonal data.

Table 1: Ethogram used for collecting behavioural data of rhino in captivity at Alipore Zoo, Kolkata (categorization is based on Hazarika and Saikia, 2010; Deka and Sarma, 2015; Dutta, 2018, Medhi and Saikia, 2020)

Behaviour categories	Types of behaviour	Description
1. Feeding	1. Grazing	Eating grasses
	2. Browsing	Proceeding towards tree twigs and leaves.
	3. Dive feeding	Feeding submerged or under-water food plants by immersing head or diving into deep water, collecting mouthful food and then chewing and engulfing above water surface.
	4. Geophagy	Licking or eating soil
	5. Feeding (offered grasses)	Eating grasses provided by zoo
	6. Feeding mixture (offered feed mixture)	Eating food mixture provided by zoo
	7. Drinking	engulfing water by immersing mouth into water body.
2. Locomotion	1. Easy Walking	Moves forward in a slow and steady manner.
	2. Running	Very fast movement in one particular direction, placing head downwards.
3. Comfort behaviour	1. Resting inside shed	Lying, sitting or standing in a resting position (inactive and relaxed condition) inside shed
	2. Resting outside shed	Lying, sitting or standing in a resting posture (inactive and relaxed condition) outside shed
	3. Sleeping outside shed	Resting outside shed with closed eyes and no alertness.
	4. Sleeping inside shed	Resting inside shed with closed eyes and no alertness.
	5. Water Wallowing	Most parts of body dip into mud and water
4. Standing	1. Standing outside shed	Standing with no movement outside shed
	2. Standing inside shed	Standing with no movement inside shed
5. Playing	Playing	Running short distance and return back and moving around tree, touching trees and particles in a relaxed way.
6. Vigilance	Vigilance	Self-monitoring (erecting ears, move frequently) against any intruders or any enemy
7. Vocalization	Vocalization	Making different sounds like <i>thet...thet...thet</i> , <i>kherak...kherak...kherak</i> or snoring type sound and so on.
8. Defecation	Defecation	Defecating in a definite location where dung heaps formed.
9. Urination	Urination	Urinating in different postures.
10. Self-maintenance	Self-maintenance	Removing unwanted organisms and things on body.

Results

A total of 7,840 minutes of diurnal behavioural data of *R. unicornis* were collected for the present study from each of the three seasons. Analyzed data were presented as percentage of time spent in different behavioural categories by *R. unicornis* in Figure 2. Among the major behavioural categories, rhino was found to spend maximum time in comfort behaviour (36.24%), followed by feeding (28.52%) and then in locomotion (12.48%) and standing (12.90%), where time was divided almost evenly and the rhino spent 3.33%, 2.76% and 2.29% time for self-maintenance, vigilance and playing activities, respectively. Rhino spent least amount of time to other miscellaneous activities such as defecation, urination,

vocalization (a total of 1.48%). Under comfort behaviour, much more time was spent in water wallowing (13%), followed by resting outside the shed (10.38%) and then in sleeping outside the shed (9.43%), whereas no sleeping inside shed was observed during the entire monsoon period. Feeding activity was almost exclusively by offered grasses (13.05%), followed by offered feed mixture (6.57%) and then by grazing (4.62%), with a very little time spent in browsing (0.95%), dive feeding (0.95%) and geophagy (0.48%).

During winter season, the mean percentage of time spent in different behavioural categories by *R. unicornis* are displayed in Figure 3. Among the major behavioural categories, in winter the rhino devoted maximum time in feeding activity

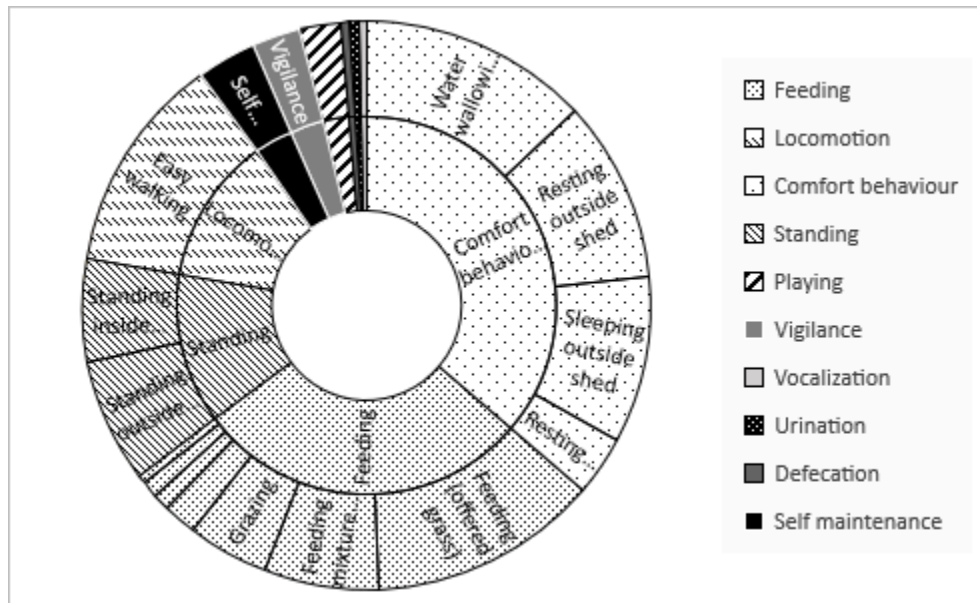


Fig. 2: Percentage of time spent in different behavioural categories by *R. unicornis* during monsoon at Alipore Zoo.

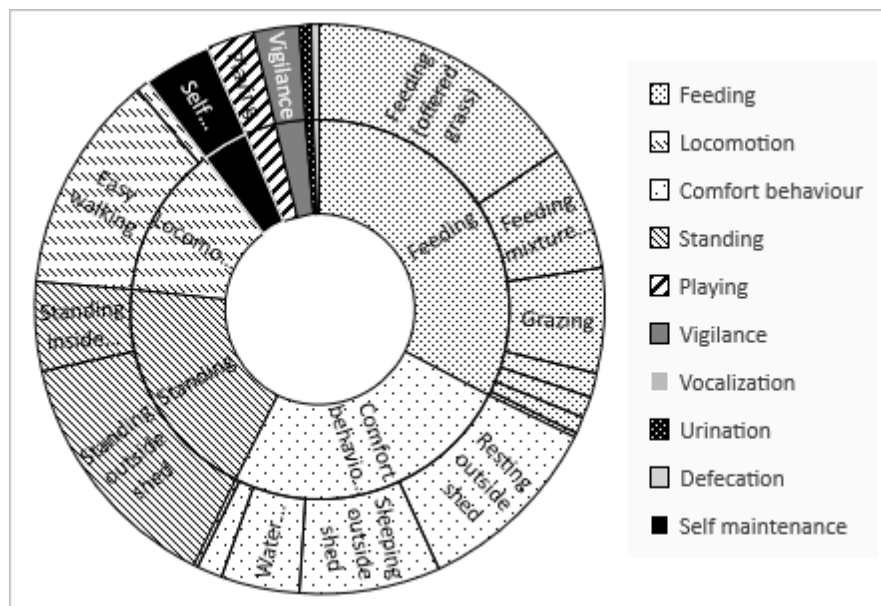


Fig. 3: Percentage of time spent in different behavioural categories by *R. unicornis* during winter at Alipore Zoo.

(32.4±2.33), followed by comfort behaviour (24.9 ±2.76), standing (19.29 ± 1.06), locomotion (13.07 ± 1.38), self-maintenance (3.88 ± 0.50), playing (2.74±0.53) and vigilance (2.57±0.59), and much less time to other miscellaneous activities like defecation, urination and vocalization (a total of 1.14%). Under feeding behaviour, rhino spent more time in feeding of offered grasses (15.71±1.79), followed by feeding of offered feed

mixture (7±1). It was noted that in winter rhino dedicated significantly more time in grazing (5.86± 0.93) compared to browsing (0.98±0.18). Rhino spent almost equal time in drinking (1.26%) and drive feeding (1.38%), and a small but significant amount of time in geophagy (0.21%). Under comfort behaviour, rhino was found to be spending his most time in resting outside the shed (10.74%), followed by sleeping outside the shed

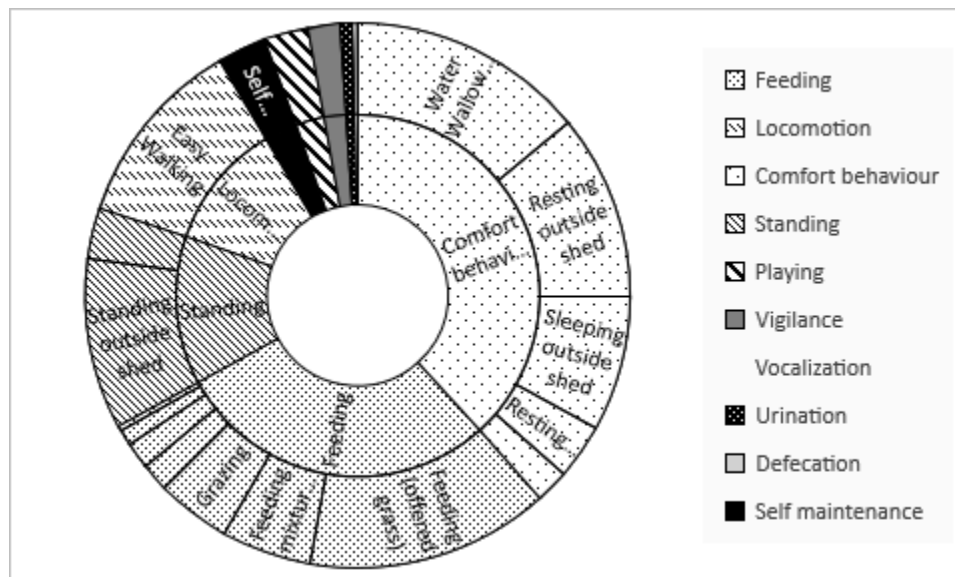


Fig. 4: Percentage of time spent in different behavioural categories by *R. unicornis* during summer at Alipore Zoo.

(8.02%) and then in water wallowing (4.48%), and least time in sleeping inside the shed (0.29%). Locomotion accounted for only 13.07% of observed samples, and was almost all of the time by easy walking, with a very little time spent in running. Similarly, under the standing activity, most of the time was dedicated in standing outside the shed and least time in standing inside the shed.

During summer season, the mean percentage of time spent in different behavioural categories by *R. unicornis* are displayed in Figure 4. Among the major behavioural categories, the rhino spent significantly higher percentage of time for comfort behaviour (38.29%), followed by feeding (28.71%), standing (13.19%), locomotion (11.38%), self-maintenance (2.9%), playing (2.57%) and then in vigilance (1.9%) activities, and significantly lower percentage of time for defecation (0.33%). No vocalization was noted during the entire observed period of summer. Under comfort behaviour, time spent for water wallowing (14.1%) was found higher, followed by resting outside the shed (11%) and then in sleeping outside the shed (7.95%). Under the feeding activity, rhino dedicated most of the time for feeding of offered grasses (14.52%) and least time for geophagy (0.29%). Time spent for grazing (4.43%) was observed significantly higher than

browsing (0.95%). Rhino spent significantly more time in standing outside the shed (10.14%) compared to standing inside the shed (3.05%).

The mean percentage of time spent in major behavioural categories by rhino in three different seasons at Alipore Zoo are shown in Figure 5. Time spent for feeding and standing activities were found significantly higher during winter season, whereas in other two seasons values of both the activities did not vary significantly (DMRT). Time devoted for locomotion and comfort behaviour by rhino was observed significantly lower in summer and winter season, respectively, while in the other two seasons data varied insignificantly (DMRT). The values of spent time percentage for playing, vigilance, vocalization, urination, defecation and self-maintenance did not show any significant variation among the three seasons.

When data of mean percentage of time spent in different subtypes of feeding activity by the rhino was compared among the three seasons (Fig. 6) it was observed that time spent for grazing, feeding of offered grasses and feed mixture was significantly higher in winter season and data of other two seasons varied insignificantly (DMRT). In case of drinking activity, rhino was found to be spending significantly more time in summer and

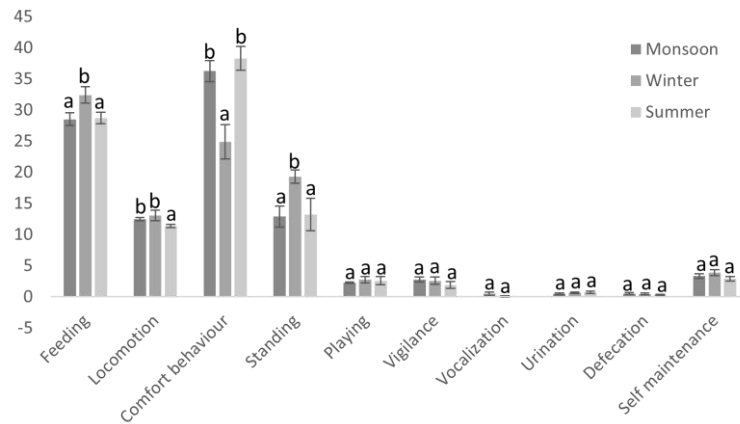


Fig. 5: Percentage of time spent in major behavioural categories by *R. unicornis* in three different seasons at Alipore Zoo. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P<0.05$) using DMRT after one way ANOVA.

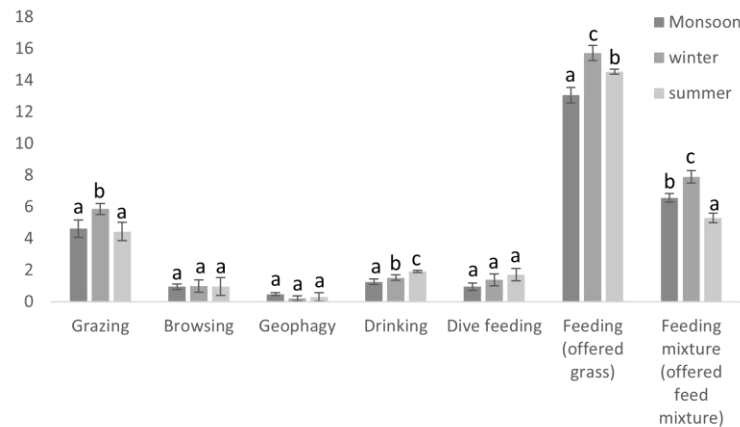


Fig. 6: Percentage of time spent in subtypes of feeding behaviour by *R. unicornis* in three different seasons at Alipore Zoo. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P<0.05$) using DMRT after one way ANOVA.

less time in monsoon. Under feeding category, time dedicated for some other behaviours such as browsing, geophagy and dive feeding did not show any significant (DMRT) variation among the three seasons.

When data of mean percentage of time spent in different subtypes of comfort behaviour by the rhino was compared among the three seasons (Fig. 7), it was noticed that significantly lower value for time spent in resting inside the shed and outside the shed was found in winter and summer, respectively. Similarly, time spent for sleeping inside and outside the shed was noted significantly lower in winter and summer,

respectively. Time spent for resting outside the shed and sleeping outside the shed was found significantly higher in winter, whereas sleeping inside the shed in summer. In case of water wallowing, rhino dedicated significantly more time in summer and less time in winter.

When data of standing behaviour displayed by the rhino was compared among seasons (Fig. 8), it was observed that time spent for standing inside the shed was significantly more in monsoon and less in winter, whereas in case of standing outside the shed, rhino preferred to spent maximum time in winter and minimum time in monsoon.

During monsoon, the mean percentage of

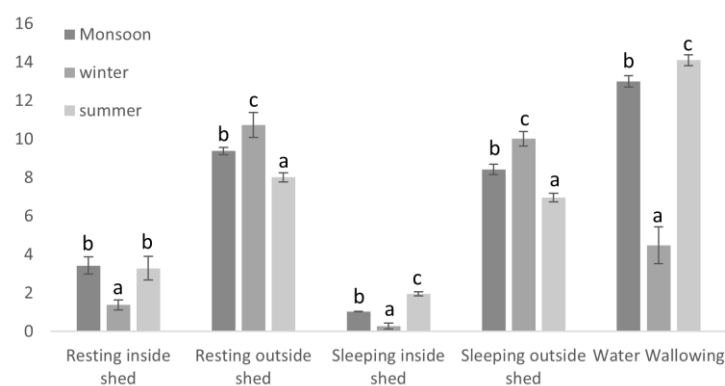


Fig. 7: Percentage of time spent in subtypes of comfort behaviour by *R. unicornis* in three different seasons at Alipore Zoo. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P<0.05$) using DMRT after one way ANOVA.

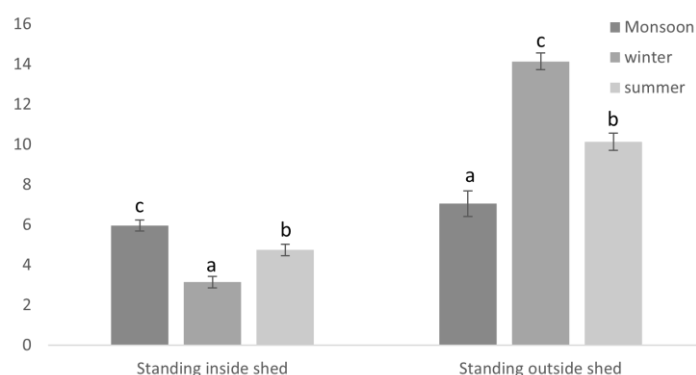


Fig. 8: Percentage of time spent in subtypes of standing behaviour by *R. unicornis* in three different seasons at Alipore Zoo. Values are mean $\pm$ SE. Bars with different letters are significantly different ($P<0.05$) using DMRT after one way ANOVA.

hourly activity pattern of *R. unicornis* from 10.00 to 17.00 hours is presented in Table 2. The peak hour of grazing was 10.00-11.00 hours, followed by 13.00-14.00 hours, whereas browsing, geophagy and drinking activities reached the peak at 13.00-14.00 hours. Rhino dedicated more time for feeding of offered grasses from 12.00-15.00 hours, whereas the peak hours for feeding of offered feed mixture was at 13.00-14.00 hours, followed by 10.00-11.00 hours and then at 12.00-13.00 hours. A similar percentage of time spent for easy walking was noticed at 10.00-11.00 hours and 14.00-15.00 hours, which were the peak hours for easy walking. Resting inside the shed was

recorded maximum at 10.00-11.00 hours, whereas resting outside the shed and sleeping outside the shed was noted maximum at 11.00-12.00 hours. Water wallowing increased from 14.00-15.00 hours (20.67%) to 15.00-16.00 hours (42.67%) during monsoon. Standing inside the shed was mostly observed at 13.00-14.00 hours, whereas standing outside the shed at 12.00-13.00 hours. Playing behaviour showed an increasing trend from 10.00 hours to 17.00 hours and was maximum at 14.00-17.00 hours. Vigilance, self-maintenance and vocalization were found more at 12.00-13.00, 14.00-15.00 and 16.00-17.00 hours, respectively. Urination was found 11.00 hours

Table 2: Mean percentage of hourly activity pattern of *R. unicornis* from 10.00 to 5.00 hours during monsoon at Alipore Zoo

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
Grazing	8.33	3.67	2.33	7.33	4.33	3.67	3.33
Browsing	1	0	0.67	2.33	1.33	0.67	0.67
Geophagy	0	0	0.33	1.33	0.67	1	0.66
Drinking	0.33	0.65	1	4.67	3	1.67	1.67
Dive feeding	0.33	0.33	0	0	1.67	3	1
Feeding (offered grass)	13	5	15.33	13.33	22.67	7.67	12.33
Feeding mixture (offered feed mixture)	11.67	2.67	9.33	12.33	3	0.33	7
Running	0	0	0	0	0	0	0
Easy walking	16.33	5.67	12	18	16.67	5.33	12.33
Resting inside shed	12	0.67	0	1.33	4.33	0	5.67
Resting outside shed	2.67	28.67	9.33	3	0.33	18.66	16.33
Sleeping inside shed	0	0	0	0	0	0	0
Sleeping outside shed	4	22.67	17.67	8.67	1.67	3.33	8
Water wallowing	4.67	9	0	0	20.67	42.67	8.67
Standing inside shed	9.67	9	6	10.33	1.33	0	4.67
Standing outside shed	9.33	3	13.34	7.67	5.33	2.67	7.67
Playing	1	2	2	2	3	3	3
Vigilance	2.34	2.67	5	2.67	2.33	2.33	2.67
Vocalization	0	0.33	0	0.34	0.67	1	1.33
Urination	0	0.33	0.33	0.67	0.67	1	0.33
Defecation	0	0	1.34	2	0.33	0	0
Self-maintenance	3.33	3.67	4	2	6	2	2.67

Table 3: Mean hourly activity pattern of *R. unicornis* from 10.00 to 5.00 hours during winter at Alipore Zoo

Behaviour	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
Grazing	9	4.83	4	7.33	2.83	10	3
Browsing	0.17	1.50	0.50	1.33	1.50	1	0.83
Geophagy	0	0	0.33	0.50	0.33	0.33	0
Drinking	1.50	1.33	0.83	1.50	1.17	1.83	0.67
Dive feeding	0.50	2	1.17	1	2.67	0.67	1.67
Feeding (offered grass)	17.50	14.17	11.83	17.17	16.83	17.17	15.33
Feeding mixture (offered feed mixture)	9.67	2.50	6.33	7.83	4.67	5.50	12.50
Running	0.33	0	3	0.83	0.17	0.17	0
Easy walking	13.50	10	11.34	14.33	12	14.83	11
Resting inside shed	1.83	0	0	2.83	1.50	0.67	2.83
Resting outside shed	9.67	17.33	16	0.17	18	6	8
Sleeping inside shed	2	0	0	0	0	0	0
Sleeping outside shed	4.17	18	7.50	6.33	1.50	12.67	6
Water wallowing	1	6.33	4.17	8.84	5.67	0	5.33
Standing inside shed	7.67	0.5	3.50	6.50	5.83	2.17	9.84
Standing outside shed	13.83	9.17	15.50	13.83	14	16.83	15.84
Playing	1.66	4.67	3.50	2.33	3.33	2.16	1.50
Vigilance	1.67	2.84	4	2.84	3	2.16	1.50
Vocalization	0	0	0	0	0.33	0.16	0
Urination	0	0.67	0.50	1.17	0.50	1.17	0.33
Defecation	0	0.33	0.67	0.84	0.84	0	0.50
Self-maintenance	4.33	3.83	5.33	2.50	3.33	4.50	3.33

Table 4: Mean hourly activity pattern of *R. unicornis* from 10.00 to 5.00 hours during summer at Alipore Zoo

Behaviour	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
Grazing	11.33	4	3.67	3	1.67	1.33	6
Browsing	1.33	2	1	0.33	0.67	0.67	0.67
Geophagy	0.33	0.33	0	0	0	0	1.33
Drinking	1.33	1.67	2.67	1.67	1	0.67	1.67
Dive feeding	0	2	1.67	2	5	1.33	0
Feeding (offered grass)	18.33	18.33	12.33	8.66	10.33	12.66	21
Feeding mixture (offered feed mixture)	8.67	4.33	8	1	1.67	7	6.33
Running	0	0	0	0	0	0	0
Easy walking	16.34	12.67	13	8.33	4	8.67	16.67
Resting inside shed	0	9.33	0	3.67	5.67	4.33	0
Resting outside shed	10	15	8.67	8	24.66	9.67	1
Sleeping inside shed	0	0	0	9.67	0	0	4
Sleeping outside shed	0	0	0	18	10	16.67	11
Water wallowing	5	6	16.66	19.33	25	24.33	2.33
Standing inside shed	3	1.67	8	1.67	3	0.33	3.66
Standing outside shed	13.33	14.67	15	8	0.67	4	15.33
Playing	3.67	2	2	1.67	2.66	3.67	2.34
Vigilance	2.67	1.67	3.33	1.67	0.33	1.67	2
Vocalization	0	0	0	0	0	0	0
Urination	0.34	1	0.67	0.33	0.67	0.33	1.67
Defecation	0	0	1	0.67	0	0.67	0
Self-maintenance	4.33	3.33	2.33	2.33	3	2	3

onwards, but peak time was at 15.00-16.00 hours. Defecation was noted from 12.00 hours to 15.00 hours, but mostly at 13.00-14.00 hours. Rhino was observed to be spending his most time in easy walking at 10.00-11.00 and 13.00-14.00 hours, in sleeping outside the shed at 11.00-12.00 and 12.00-13.00 hours, in feeding of offered grasses at 14.00-15.00 hours, in water wallowing at 15.00-16.00 hours and in resting outside the shed at 16.00-17.00 hours.

During winter (Table 3), grazing and drinking activities were observed more at 15.00-16.00 and then in 10.00-11.00 hours. Feeding of offered grasses was observed peak at 10.00-11.00 hours and the feeding of offered feed mixture and dive feeding reached the peak at 16.00-17.00 and 14.00-15.00 hours, respectively. More time spent for browsing was noted at 11.00-12.00 and 14.00-15.00 hours. Rhino displayed geophagy behaviour from 12.00-16.00 hours, which was maximum at 13.00-14.00 hours. Peak hours for resting inside shed and outside shed were at 13.00-14.00 hours and 14.00-15.00 hours, whereas for sleeping inside shed and outside shed was at 10.00-11.00

hours and 11.00-12.00 hours, and for standing inside shed and outside shed was at 16.00-17.00 hours and 11.00-12.00 hours. Rhino was noticed to spent more time in water wallowing at 13.00-14.00 hours. Within standing activity, standing outside the shed was found maximum at 15.00-16.00 hours and standing inside the shed was at 16.00-17.00 hours. Some miscellaneous behaviours like playing, vigilance, vocalization, urination, defecation and self-maintenance were noted peak at 11.00-12.00, 12.00-13.00, 14.00-15.00, 13.00-14.00, 13.00-15.00 and 12.00-13.00 hours, respectively.

When activity patterns were compared within hour, it was found that rhino spent more time in feeding of offered grasses from 10.00 to 11.00, 13.00 to 14.00, 14.00 to 15.00 and 15.00 to 16.00 hours, in resting outside shed from 11.00 to 12.00 hours, in standing outside the shed from 12.00 to 13.00 and 16.00 to 17.00 hours.

During summer (Table 4), the peak hours of grazing, browsing and drinking were at 10.00-11.00, 11.00-12.00 and 12.00-13.00 hours, respectively. From 16.00 hours to 17.00 hours,

was the peak hour for the feeding of offered grasses, then from 10.00 to 12.00 hours. Feeding of offered feed mixture was found maximum at 10.00-11.00 hours. The peak hours for easy walking were 10.00-11.00 and 16.00-17.00 hours. Resting inside shed and outside shed were noticed higher at 11.00-12.00 and 14.00-15.00 hours, respectively. Sleeping behaviour both in inside and outside the shed was noted more at 13.00-14.00 hours. Similarly, standing inside and outside the shed were found most at 12.00-13.00 hours. From 14.00 hours to 15.00 hours, was the peak hour for water wallowing. The peak hour of playing and self-maintenance was 10.00-11.00 hours, whereas vigilance and urination were noted maximum at 12.00-13.00 and 16.00-17.00 hours, respectively. For defecation, the rhino spent more time at 13.00-14.00 and 15.00-16.00 hours.

Comparison of hourly activity budget of rhino among the three different seasons at Alipore Zoo are presented in Figure 9. When activity patterns were compared within hours, it was observed that rhino spent more time in feeding of offered grasses at 1st two hours and easy walking at the last studied hour (16.00-17.00 hours). Water wallowing was found maximum for four hours from 12.00-16.00 hours. When 10.00-11.00 hours was considered, it was observed that time spent for grazing, browsing, geophagy and feeding of offered grasses were higher during summer, whereas for drinking and dive feeding were noted maximum during winter and for feeding of offered feed mixture was more in monsoon. Under locomotion, running was maximum during winter and easy walking in other two seasons. Resting inside and outside the shed was observed most in monsoon and summer, respectively. Both the sleeping inside and outside the shed were found maximum during winter. Water wallowing was maximum in summer, then in monsoon. Standing inside and outside the shed were noted higher in monsoon and winter, respectively. Time spent for the other miscellaneous behaviours such as playing, vigilance, vocalization and self-maintenance were more in summer.

From 11.00 to 12.00 hours, time spent for the behaviours such as browsing, geophagy, drinking, dive feeding, feeding of both the offered grasses and feed mixture, easy walking, resting inside shed and standing outside shed were maximum during summer, whereas grazing and other miscellaneous behaviours were more in winter and water wallowing, resting and sleeping outside the shed, and standing inside the shed were found at peak during monsoon.

From 12.00 to 13.00 hours, under feeding behaviours, time spent for grazing was more in winter, for browsing, drinking and dive feeding in summer and for feeding of offered grasses and feed mixture in monsoon. Resting and standing outside the shed were more in winter, whereas easy walking, water wallowing and standing inside the shed were most in summer.

From 13.00 to 14.00 hours, under feeding activity, grazing, browsing, geophagy, drinking and feeding of offered feed mixture were maximum during monsoon, whereas feeding of offered grasses was in winter and dive feeding in summer. Time spent for easy walking, standing inside the shed, vocalization and defecation were noticed higher in monsoon, standing outside shed, playing vigilance, urination and self-maintenance were maximum during winter, and resting and sleeping inside and outside the shed, and water wallowing were observed more during summer season.

From 14.00 to 15.00 hours, during monsoon season, rhino spent maximum time for the activities which were grazing, geophagy, drinking, feeding of offer grasses, easy waking, vocalization and self-maintenance, whereas during winter season for browsing, dive feeding, feeding of feed mixture, running, standing inside and outside the shed, playing, vigilance and defecation. On the other hand, during summer, maximum time was spent for resting inside and outside the shed, sleeping outside the shed and for water wallowing.

From 15.00 to 16.00 hours, during winter, rhino spent more time in grazing, browsing, feeding of offered grasses and drinking, whereas

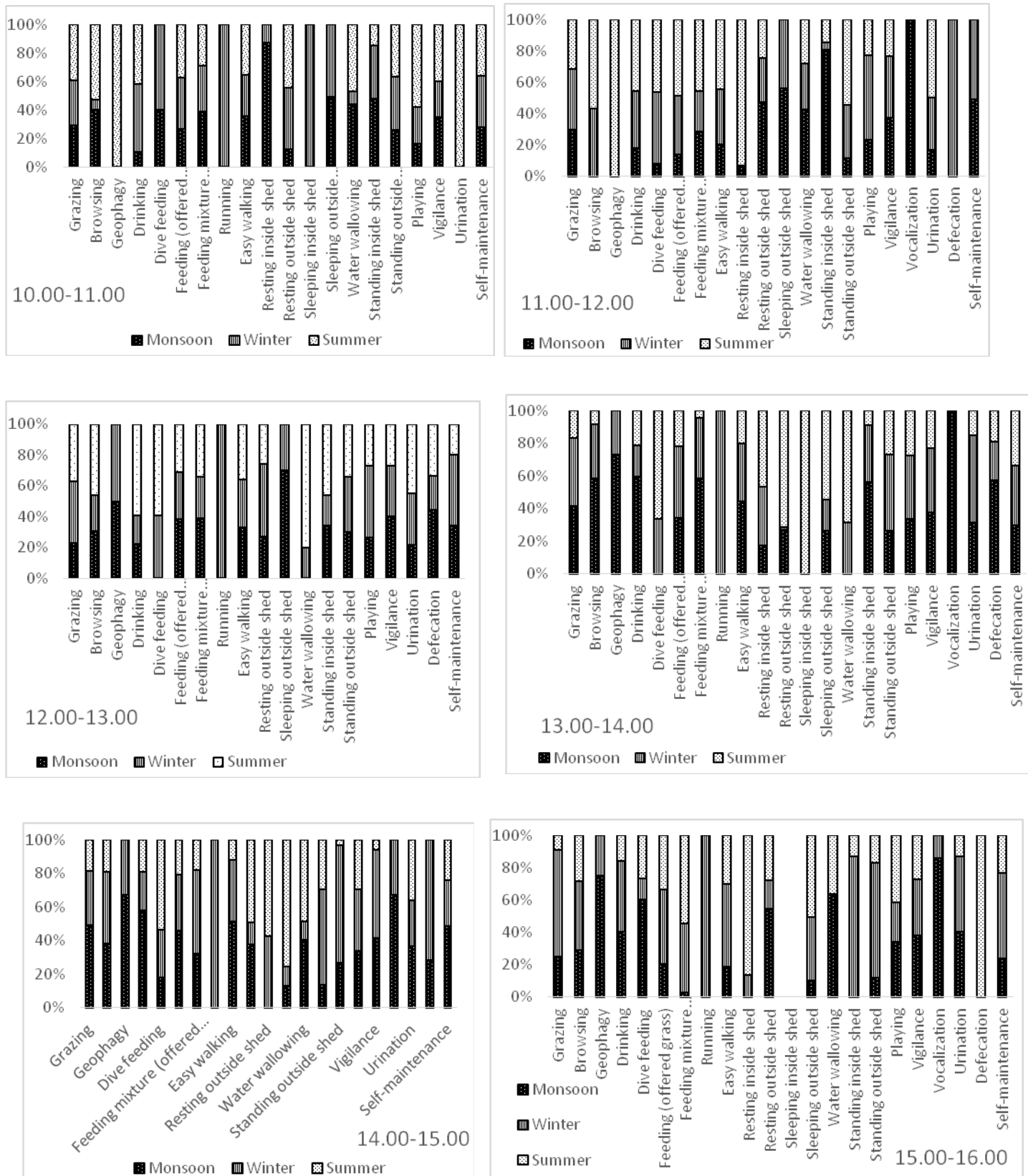


Fig. 9: Hourly activity budget of *R. unicornis* in different seasons at Alipore Zoo.

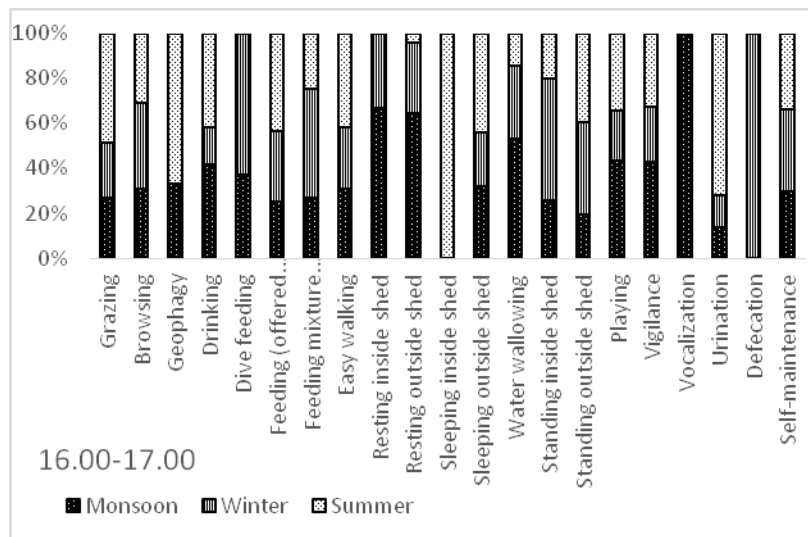


Fig. 10: Activity budget of *R. unicornis* in different seasons from 16.00 to 17.00 hour at Alipore Zoo.

during summer, feeding of offered feed mixture. On the other hand, during monsoon season, most time spent for resting outside the shed, water wallowing, vigilance and vocalization activities, and during winter for running, easy walking, standing inside and outside the shed, urination and self-maintenance activities, whereas during summer for sleeping outside the shed, playing and defecation.

From 16.00 to 17.00 hours (Fig. 10), rhino dedicated more time in grazing, geophagy, drinking and feeding of grasses during summer, in browsing, dive feeding and feeding of feed mixture during winter. During monsoon, rhino spent more time in resting inside and outside shed, water wallowing, playing, vigilance and vocalization, during winter in standing inside and outside the shed, defecation and self-maintenance, and during winter in easy walking, sleeping inside and outside the shed, and in defecation.

Discussion

Study on captive Great Indian one-horned rhino's behavioural pattern, activity budget and also the behavioural ecology are the most crucial aspects for their conservation, management and also for their well-being in captive condition. Beside these, as rhinos are one of the primitive herbivorous mammals, they possess some unique behavioural features which are related to their survival

perspective measure in wild (Hazarika Saikia, 2010). Inadequate information on the behavioural ecology of Indian one-horned rhino are available as limited studies were conducted on them either in national park or in sanctuary, among them few are from last ten years and mostly are of 40-years back data. No detailed studies on the behavioural pattern and activity budget were carried out on captive rhino. In the current study on captive rhino, the recorded major behaviours and their subtypes were almost similar to the non-breeding behaviours of rhino of the previously studied investigation in the Rajiv Gandhi Orang National Park, Assam, India except the agonistic, local migration and crop raiding behaviours which are possibly found when they are in community in natural habitat (Hazarika and Saikia, 2010). The percentages of all the activities displayed by rhino generally change with the change in the environmental factors, seasons and change in the quality of food throughout the year (Medhi and Saikia, 2020).

In the present study at Alipore zoo, studied rhino spent most time in comfort behaviour, followed by feeding activity during monsoon and summer, while it was opposite in winter. This finding was supported by the previous works, carried out in Kaziranga National Park and Rajib Ghandhi Orang National Park where also maximum feeding was noticed in winter season

(Hazarika *et al.*, 2013; Medhi and Saikia, 2020). The present investigation revealed that feeding is one of the dominant activities displayed by the Indian rhinoceros. Rhino spent maximum time in feeding activity that depicts when they need huge amount of food to maintain their large-sized body and other daily activities. According to Owen-Smith (1988) and Medhi and Saikia (2020), as rhinoceros are hindgut fermenter, they digest their food faster than other larger herbivores and therefore, they require more food for their body. In wild, rhino graze for a long time as they engulf a very little amount of food per bite, this is the other reason of investment of higher time in the feeding activity (Medhi and Saikia, 2020). A similar kind of findings were reported by Laurie (1978) and Hazarika and Saikia (2010). Maximum time spent in feeding activity was also reported in several mega-herbivores such as wild black rhino (Joubert and Eloff, 1971), wild white rhino (Jordan, 2010), wild elephant (McKay, 1973; Saikia, 2012) and wild swamp deer (Ahmed and Khan, 2014). In the earlier study on the feeding activity pattern in primates, Clutton-Brock (1977) observed that the percentage of feeding activity in primates change with the availability of food, its nutritional value and the prevailing ecological factors across the year. Several research workers, throughout the globe, reported that mega-herbivores always maintain the balance of calorie and nutrient requirement either by enlarging the bite-size or by increasing the time allocation in feeding activity (Spalinger *et al.*, 1988; Laca *et al.*, 1994). In wild rhino consume more during winter than monsoon as in winter the greenness of grasses and its nutritional values in terms of crude protein, phosphorus, sodium etc. decline, while in monsoon it again increases (Shrader *et al.*, 2006). Though in captive condition food was provided by zoo authority, rhino retain the feeding activity pattern in a similar way as found in wild.

In wild, generally more time allocation for feeding activity is always associated with the maximum time investment in locomotion to get their required amount of food in the habitat. More time investment in feeding activity by grazing

might be the possible reason for maximum locomotion activity. Medhi and Saikia (2020) reported that time spent in locomotion was more in winter, then in monsoon in case of wild rhino. In the current study similar observation on the mean time spent in locomotion by the captive rhino was recorded. According to the report of Dutta *et al.* (2021), during monsoon percentage of spent time in walking is only 6%, while in the current study it was more than double (12.48%). These alteration in time budget of walking activity might be due to their captive condition.

Wallowing is a unique and important activity displayed by rhino mainly for thermoregulation during hot summer (Medhi and Saikia, 2020). Present study supports the fact and stated that wallowing was found maximum during summer, followed by monsoon and then in winter. According to Ghose (1991) and Tanaka and Tanaka (1982), water wallowing is the strategy to get rid of ectoparasites such as flies, ticks, etc. which are found more in number during monsoon and less during winter. Earlier reports stated that wallowing reached peak in monsoon and declined in winter (Dinerstein, 2003; Hazarika *et al.*, 2013; Dutta and Mahanta, 2016; Medhi and Saikia 2020).

Present study revealed that, resting was more in summer, followed by monsoon and then in winter. Medhi and Saikia (2020) also observed a similar result for resting activity and showed that it was positively associated with temperature and rainfall. Maximum resting was observed during summer and monsoon as they invest less time for feeding activity due to availability of more nutritious food and thereby remains surplus of time that increases the proportion of resting activity. In contrary, Dutta *et al.* (2021) and Hazarika *et al.* (2013) reported higher resting behaviour during monsoon.

Vigilance is also an important activity displayed by Indian rhino. They carefully and continuously observed around them and watched the intruder, either any enemy or foreign object or other individuals. Medhi and Saikia (2020) reported a higher vigilance activity during

monsoon, followed by summer and then in winter. From monsoon a greater number of tourists start to visit the national parks, hence, vigilance activity of rhino was found maximum in monsoon. Then in winter, it declines as rhino become used to with the tourists and in summer it become least due to decrease of human interference. As a similar type of human interference was noticed in Alipore zoo, the vigilance pattern of rhino was also similar as in wild. Rhino was found to defecate at the same location in their enclosure for the entire study period. This observation was supported by Medhi and Saikia (2020) and Laurie (1978), although, study was conducted on wild rhino.

Study performed in different hours from 10 am in the morning to 5 pm in the evening, it was observed that feeding behaviour was more at 10.00-11.00 hours and at 16.00-17.00 hours. Medhi and Saikia (2020) supported this observation partially and stated that feeding behaviour reached peak during 16.00-17.00 hours. Medhi and Saikia (2020) found highest locomotion at morning period. In the present study, maximum locomotion was noted at 10.00-11.00 hours as mentioned in earlier report and also at 13.00-15.00 hours where, greater proportion of locomotion was noted which might be due to a greater percentage of grazing of that period. Water wallowing showed peak at 13.00-15.00 hours, when temperature was maximum. A similar result of water wallowing was observed by Medhi and Saikia (2020).

Conclusion

It can be concluded from the present study that Indian one-horned rhino displayed a marked behavioural pattern not only in the three seasons but also in their hourly activity budget. Rhino spent most time in feeding activity, followed by comfort behaviour during winter, whereas during monsoon and summer they showed maximum comfort behaviour, followed by the feeding activity. Under comfort behaviour, resting was more in summer, followed by monsoon and then in winter. Mean percentage of time devoted for locomotion was more in winter, followed by

monsoon and summer. Wallowing was found maximum during summer, followed by monsoon and then in winter. A higher percentage of vigilance activity was found during monsoon, followed by summer and then in winter.

Feeding activity was more at two times, 1st at 10.00-11.00 hours during entire study period and other at 13.00-15.00 hours during monsoon, at 13.00-16.00 hours during winter and 16.00-17.00 hours during summer. Locomotion was more at 10.00-11.00 hours and 13.00-15.00 hours during monsoon, at 12.00-14.00 hours and 15.00-16.00 hours during winter and at 10.00-11.00 during summer. Resting behaviour was maximum at 11.00-12.00 hours, 14.00-15.00 hours and 14.00-15.00 hours during monsoon, winter and summer respectively. Water wallowing showed peak at 15.00-16.00 hours during monsoon, 13.00-14.00 hours during winter and 14.00-16.00 hours during summer.

Hence, the present study on the behavioural pattern and activity time budget of Great Indian one-horned rhino, would able to provide sufficient knowledge and detailed understanding about their different activities under an *ex-situ* environment. This information might be useful for the identification of captive environmental challenges and behavioural associated problems. Therefore, behavioural study of captive Great Indian one-horned rhino, could be a major tool for their sound management and successful *ex situ* conservation in Alipore Zoological Garden, Kolkata, India.

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