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The effect of day-night, age-sex and climatic factors on the activity budget of Great Indian One-horned Rhinoceros in Kaziranga National Park, Assam, India

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ABSTRACT

Behavioural activity budgeting of Great Indian One-horned Rhinoceros-*Rhinoceros unicornis* was carried out from May 2016 to July 2018 in Kaziranga National Park to find out the overall activity patterns covering variations in seasons, activities in 24 hours time periods, age/sex differences and its effects on environmental gradients of light, temperature, humidity and rainfalls. Study was performed using Scan Animal Sampling and camera trapping methods. Altogether 1014.25 hours of diurnal behavioral data and 2847 camera trap photographs data for night activities were gathered. All data were analyzed using SPSS software. Study revealed that, rhinoceros showed significant variation in activities among months, seasons and in different periods of the day. In all the occasions, the rhino spent maximum time in feeding activity. Amongst season, maximum feeding was found during winter season followed by retreating monsoon, pre-monsoon and monsoon. Feeding, locomotion and vigilance were higher in dark, whereas, resting and wallowing were higher in day period. Again, locomotion and vigilance were higher in winter and re-treating monsoon, while wallowing and resting were higher in monsoon and pre-monsoon. Night study revealed that, wallowing was higher in winter than other season. Study showed higher feeding activity in females, whereas locomotion and wallowing were higher in males. There was a significant negative correlation between feeding and locomotion with temperature, humidity and rainfall, whereas wallowing showed significant positive correlation with temperature, humidity and rainfall.

Key words: Behaviour; *Rhinoceros unicornis*; seasonal variation; Kaziranga National Park; Diurnal and nocturnal activity patterns; Environmental gradients.

INTRODUCTION

Conservation and management strategies of wildlife species have many aspects but understanding the behavioural aspects and their characteristics are considered as key components for developing the conservation strategies (Hutchins & Bjornhag, 2006). In certain occasions, the behavioral components are worth mentioning for the conservation purposes (Dingle *et al.,* 1997). In ecological point of view, information's gathered from the studies on the behavioural cataloguing and activity budgeting provides vital clue for the healthiness of a habitat that reflects the resource status of the species in the habitat (Lehner, 1998). *Rhinoceros unicornis* is an IUCN threatened species and survive only in a few pockets of India and Nepal (Owen-Smith, 1988). The major threat factors of the species in their distribution ranges are such as poaching, habitat loss and habitat fragmentation. Kaziranga National Park (KNP) of Assam has harboared highest population of *Rhinoceros unicornis.* Due to continuous conservation efforts of the forest department, the species population has been increased from 366 numbers in 1966 to 2413 numbers in 2018 (Assam Forest Department, 2018). In behavioural point of view, *Rhinoceros unicornis* is rarely found in groups except during wallowing, mating (Laurie, 1978) and heavy flood period. Thus, they need larger territory for their survival compared to social groups of wildlife. The increasing population of great India rhino in KNP brings them to competition against resource utilization. Every behavioural aspect is an output of either intrinsic or extrinsic factors (Lehner, 1998). The resources (Clutton-Brock, 1977; Zielinski *et al*., 1983), competitors, environmental factors (Clutton-Brock & Harvey, 1977; Gaulin, 1979; Struhsaker & Leland, 1979) and habitat availability are certain extrinsic factors that affect the behavior of an organism. Many ecological studies on the behavioural pattern like territorial and sexual behaviour (Ripley, 1952), behaviour and habitat patterns (Laurie, 1978), reproductive behaviour (Kakoti & Rajkonwar, 1972), role of rhinoceros in seed dispersal (Dinerstein & Wemmer, 1988), food habit and feeding pattern, and time and activity pattern (Hazarika & Saikia, 2010, 2012; Hazarika *et al.*, 2013), stray behaviour and patterns, population demography and seasonal movement pattern (Bhatta, 2011; Bhatta & Saikia, 2013), relation of behaviour to different ecological aspects (Ghose, 1991) have been done so far across the globe. Although, the ecological and behavioural studies are likely to be very important for the conservation strategies of the species but very limited numbers of studies have been carried out in the rhino range areas (Dutta & Mahanta, 2018). Again, the past studies on rhinoceros behaviours are scanty and confined to daytime behaviours only and, no such attempt was made to know the night and dark periods covering 24 hours period except few sporadic information during full moon night by Laurie (1978) and Hazarika & Saikia (2010). The subjective

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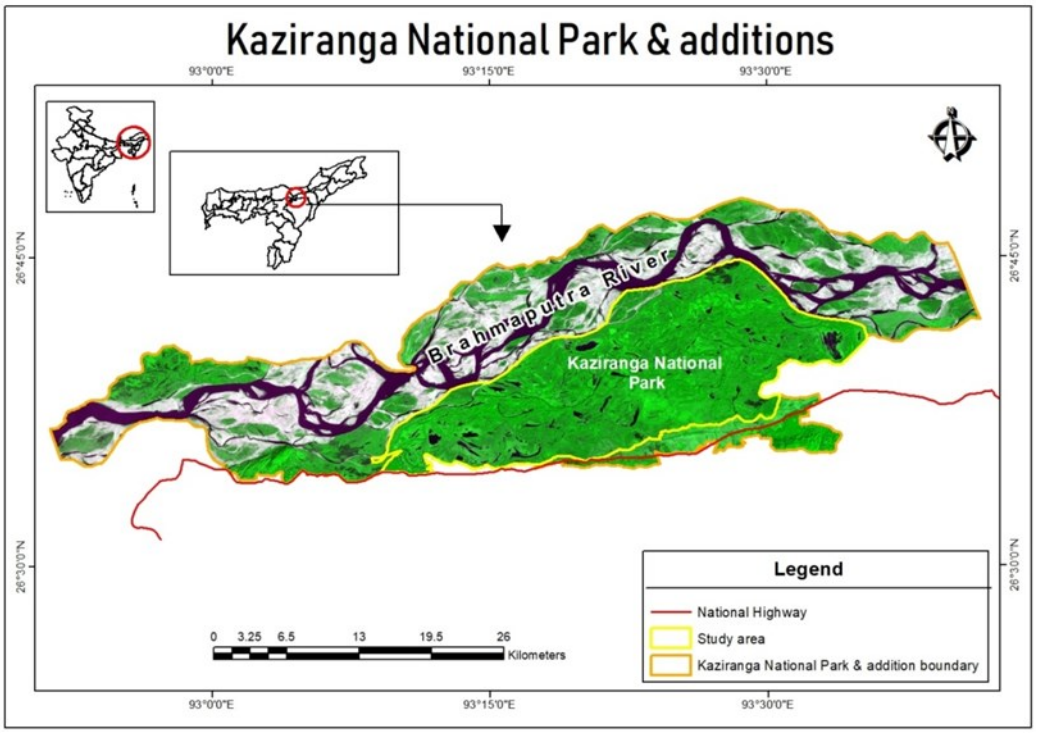


Figure 1. Map of study area Kaziranga National Park.

observation of mating, territoriality and aggressive behaviour was documented in KNP by Gee (1964, 1950), but the population was limited to near 400 individuals during that time. However, in recent times, the rhino population is increasing in KNP that enhances reduced territory and home range, even though, the rhino keeps loose territory (Ripley, 1952). Consequently, it is very important to study the behavioural aspects of rhinoceros in an area with increasing trend of population and to provide the additional information for future conservation management. Thus, the present study is an attempt to fulfill the needs of the current situation. Again, the activity patterns of temporal behaviour are related to metabolism and energetic constraint and changes with respect to environmental gradients (Bronikowski & Altmann, 1996; Halle & Stenseth, 2000; Hill, 1999). Hence, the study of these relationships explores ecological influences on the behavioral pattern of the rhino species in a greater way. Thus, the present study has mainly emphasized the effect of day-night, age-sex and climatic factors on the activity budget of Indian rhinoceros in KNP.

Study area

The present study has been carried out in Kaziranga National Park (KNP) of Assam, India. KNP is sandwiched between southern bank of Brahmaputra valley and the northern foot hills of Mikir-Karbi-Anglong hills. It is within the coordinates of 26°30' N to 26°45' N latitudes, and 93°08' E to 93°36' E longitudes, with the stretches of 40 km in length from east to west and 13 km in width from north to south. The Park covers an area of 859.4 km^2 including all the additions (Mishra *et al.*, 2005). The present study includes 482.9 km^2 area (Kushwaha, 2008) that is considered as the core area (as per Department of forest, Government of Assam; Figure 1). The river Brahmaputra flows through the park enriching the soil by minerals/nutrients that supports the grassland vegetation. Kaziranga National Park comprises four main habitats viz., grassland, woodland, wetland and sand-bars (Kushwaha & Unni, 1986). The park is dominated by grasses viz., *Saccharum sp., Imperata cylindrica, Typha elephantina, Neyraudia reynaudiana, Erianthus filifolius, Cymbopogon pendulus, Tamarix dioica, Alpinia allughas, Veteveria zizanioides, Themeda arundinacea* (Mishra, 2005; UNEP, 2011). The climate of Kaziranga is subtropical monsoonal climate (Rodgers *et al.,* 2002). The park experiences four seasons viz., pre-monsoon, monsoon, re-treating-monsoon and winter (Borthakur, 1986). The winter season is mild and dry, with a mean temperature of 25 °C and 5 °C. May is hot, with a highest temperature of 37 °C. Monsoon starts from the month of June and continue till August. During July and August, three-fourth of the western region of the park remains submerged, due to rising water level of Brahmaputra River. The total annual rainfall in the study area is about 230 cm or 2293 mm (Taher & Ahmed, 2005; Deka *et al.*, 2013).

MATERIALS AND METHODS

Study has been carried out from May, 2016 to July 2018 in KNP, to understand the activity budget of *Rhinoceros unicornis*. Study has been carried out as per the methods of Laurie (1978, 1982), Hazarika & Saikia (2010). Night survey for behavioural activities budget was done using camera trapping method as per Nielsen (1979). However, the efforts of night survey could not be performed as extensively as it was done in diurnal survey owing to certain unavoidable technical reasons like heavy flood and heavy showers during summer that created unsuitability for establishing camera traps stations. The behavioural nomenclatures were used as per Laurie (1978), Hazarika & Saikia (2010), whereas, the Breeding behaviours were used as per Stoops *et al.* (2014) with some modifications. Diurnal study was conducted from 06:00 hours in the morning to 18.00hours in the evening. The study was done for 12 days per month except monsoon season, where only 5 days/month were maintained due to heavy

showers and flood effects. For the nocturnal study of activity pattern of Indian rhinoceros, nine cameras were placed randomly in stratified habitats in the park at the waist height for the month of April & May, 2018. Moreover, the photographic evidences of data from 144 numbers of camera traps data of tiger-census in the stratified areas of the park (Sources: Department of Forest, Bokakhat, Assam) was also used which included the data from December to May in the year 2016-17 and 2017-18

Direct observation of *Rhinoceros unicornis* during the day hours were made along the roadsides transacts, in and around the water holes and from the convenient watch towers of the park. Behavioural data were collected in hourly basis when encountered, in an interval of 5 minutes (i.e. 5 minutes scan and 5 minutes gap procedure, as per Altmann, 1974). Uniformity was maintained during data collection to represent all age and sex compositions as well as habitats of great Indian one horned rhinoceros in the study area. The photographs for night behavioural study were collected periodically from the camera traps and behavioural data were noted down with time. The photographs from the tiger census camera trapping were collected from the Divisional Forest Office, Bokakhat. The camera trapping was not possible during monsoon and retreating monsoon due to occurrence of heavy flood during study periods. A total 1014.25 hours of behavioral samplings that includes 12,171 numbers of scan samples was obtained for diurnal activity budgets and 2,847 photographs from camera trapping were obtained for night behavioural activity budgets during study period. As the resting behaviour was not available in the photographs, hence, only the active behaviours at night period were considered for analysis. The data for environmental gradients were collected for the required time periods of study from www.world weatheronline.com for analysis (Access date -11th March, 2019).

Data analysis

The software used for the data analysis was M.S. Excel, version 2007 and SPSS version 16.0. The activity budgeting data were pooled together in monthly and age/sex class wise (male, female, sub-adult and calf) basis. The mean of each group was computed in monthly basis to obtained monthly activity budgets for all age and sex classes to avoid potential biasness owing to overlapping of samples. From the monthly budget data, the seasonal and annual activity budgets were calculated. Night observation data was not used for seasonal analysis owing to insufficient data. One Way ANOVA was performed to assess the significant differences in the activity patterns for monthly and seasonal data. Independent T-test was done to analyze the difference between male-female and between females with and without calf. Correlation was done to see the effect of environmental gradients in different behaviours.

RESULTS

Behavioural cataloguing

Altogether two basic behavioural types were recognized viz., Non-Breeding and Breeding behaviours. Non-breeding behaviour was dilated into six sub-types and breeding behaviours dilated 15 sub-types for *Rhinoceros unicornis* in Kaziranga National Park. The sub- types of breeding behaviours were categorized under three main groups viz., pre-mating, mating and post mating behaviours. All the behaviours were catalogued systematically and described properly (Table 1&2).

Yearly mean activity budgets

Altogether 1014.25 hours of diurnal bahaviour data and 2,847 occasion's night behaviour data of *Rhinoceros unicornis* were obtained during present study. Analysis showed that, the rhinoceros in KNP has devoted maximum time in feeding activity (mean % ±SD: 60.22±10.49, followed by wallowing (15.70±13.33), resting (13.21±7.27), locomotion (6.58±3.13), vigilance (3.67±1.55) and least amount to other miscellaneous activities (0.62±0.59) during diurnal activity budget (Table 4). Again, the diurnal activity of feeding behavior was highest between 14.00- 18.00hrs. (74.61% to 79.59%) and lowest between 07.00-10.00hrs. (45.63% to 51.52%). Whereas, the resting behaviour reached the peak during 08.00-11.00hrs. (20.39 to 37.22%) and later, it declined drastically from 18.00hrs. onwards (0.69%). However, the wallowing activity increased from 11.00hrs. (6.23%) to 15.00hrs. (11.87%) during study period. On the other hand, locomotion was more during 6.00-8.00hrs. (30.06%) and throughout the night period (26.58 to 35.37%; Table 3; Figure 2).

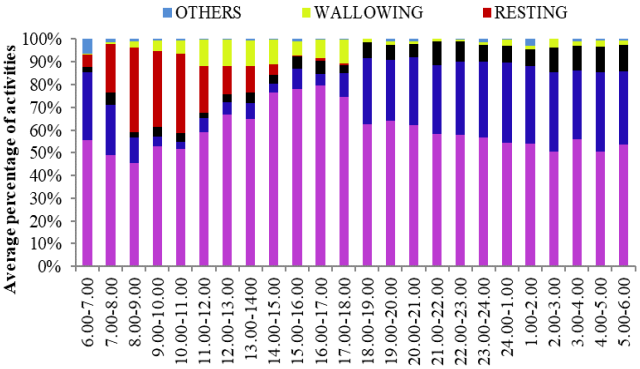


Figure 2. Hourly Activity patterns of *Rhinoceros unicornis* for 24 hours (day and night) period in the study area (data were taken for 24-hour time period of rhino in the study area by aiding Night Camera trap data).

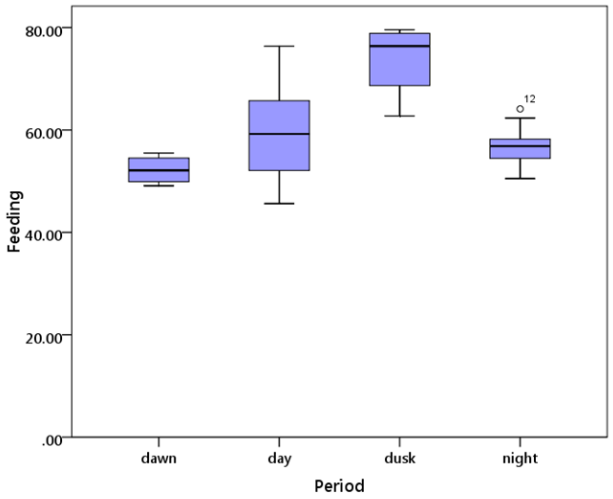
Study performed in different period of 24 hours showed that, feeding behaviour reached at peak during dusk (from 16.00-17.00hrs.; 73.77±7.65), followed by day (from 07.00-16.00 hrs.; 59.55±10.54), night (17.00-04.00 hrs.; 57.16±4.19) and dawn (04.00-07.00 hrs.; 52.20±2.85); Table 4; Figure 3.1a). Locomotion was found to be highest during night period (31.86±2.90), followed by dawn (29.77±5.47), dusk (13.33±10.58) and lowest during the day (5.92±5.58) period (Table 4; Figure 3.1b). However, resting was found to be higher during daytime (22.08±13.05) (Table 4; Figure 3.2d). The vigilance behaviour was found highest during low light period (dawn: 7.60±4.51; dusk: 5.33±1.31 and night: 8.42±1.96) and decreased during daytime (3.48±0.80; Table 4; Figure 3.2c). Wallowing on the other hand showed peak during day period (8.50±3.77; Table 4; Figure 3.3f) and declined towards dawn (1.55±1.00). Wallowing was also found during night hours. One-way ANOVA showed significant variations in feeding ($F_{3, 20}$=7.10, p=0.002), locomotion ($F_{3, 20}$ = 39.89, p=0.000), wallowing ($F_{3, 20}$ =12.77, p=0.000), resting ($F_{3, 20}$ =11.02, p=0.000) and vigilance ($F_{3, 20}$ = 7.05, p=0.000) among different periods of the day.

Monthly and Seasonal Activities budget

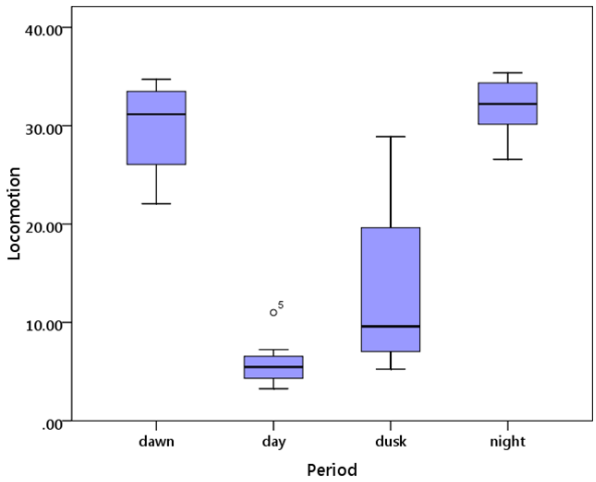
Comparison of behaviours among months and seasons during the present study showed significant variations.

Table 1. Non-Breeding Behaviour and their description

Behaviour	Description
Feeding	Feeding is the process of searching food resources of any edible form and biting and consuming/swallow it up. The process of feeding includes grazing, browsing, drinking, lactating, geophagy and coprophagy. Grazing was more common in great Indian rhinoceros in KNP than browsing. During this process, the Rhino ingested grasses with their prehensile lip and incisor teeth's. Browsing was found to be occasional, that involved the intake of edible leaves and twigs of shrubs/trees. Geophagy involves licking of the soil to fulfill mineral requirements. They licked soil with the help of their tongue and teeth. Lactating was found in case of calves that included sucking on mother's milk. Coprophagy was also seen in KNP which is the process of feeding mother's dung by the calves to get gut microbes (Plate-1. a-f; Plate-3.m, n).
Locomotion	Locomotion is the movement activities of great Indian one horned rhinoceros from one place to another. It includes slow walking, walking fast, running and galloping. It was observed that, while walking, they look forward with head slightly upward ears pointing backward direction. However, sometimes the ears remain in their usual position. Galloping is the process of fast movement when they run with jumping. Galloping was found during frightened situation. However, running was common during territorial fighting and competition for mating process (Plate 2. j, k).
Vigilance	Vigilance is the process of self-monitoring of rhino against any intruders within a reach or any enemy in and around the rhino. During vigilance behaviour, it was seen that their ears remained erect, move frequently and try to locate the existence of the intruders/or individual of same species etc. Their poor eye sight leads to gaze longer time for vigilance behaviour (Plate 2. l).
Resting	Resting behavior is found to be body relaxing posture of the great Indian rhinoceros. While resting, they lay on the ground and closed their eyes and went to sleep. Sometimes they lay on the ground without closing their eyes and get up immediately from resting posture when felt the existence of any intruder. In that situation, it was seen that the rhino stayed alert for few seconds and then ran towards the intruder or flushed away (Plate 2.i).
Wallowing	Wallowing is another type of relaxing posture observed in great Indian rhinoceros in KNP. It was of two types; mud-wallowing and water-wallowing. During mud wallowing posture, they rolled their body in the wet mud and kept half of the body under mud to get rid of flies and ticks or from sun shine. Whereas, in water wallowing they sub-merged their body under water leaving their nose above the water. Sometimes they also kept both nose and eyes above water surface (Plate 2. g, h).
Miscellaneous behaviour (Others)	The behavioural postures that existed for a short moment or persisted for very short period of time and not frequent like others were termed as miscellaneous behaviours. However, some of the miscellaneous behaviours have certain originality and not generally seen in other animals, were need to be explained in details. Thus, they were described below to understand their distinctiveness. **(a)Vocalization-** Vocalization was seen with various other behaviours. The pattern of vocalization was different during different bahaviour. It was found during fighting between two males, while mother approaching their calf, while chasing of male-female, when they were frightened etc. In every occasion they made different sound viz., *thet...thet...thet, kherak...kherak...kherak*, sometimes snoring type sound and so on. Both female and male produced some unique whistling sounds during pre-mating period after the female submission. **(b)Agonistic behavior**- The behavioural postures that were used for fighting with other individuals of the same species or any other strange animals encountered within the habitat were regarded as agonistic or aggressive behaviour. While possessing the agonistic or aggressive behavior, the Indian rhino snored, chased and attacked the enemy. Again, when the rhino attacked other animals, they mostly bit each other and hit the opponent by their head and horn. Shedding of horn was found to be common during this behaviour. Serious injury was also seen during aggressive behaviour and occasionally leads to death. (Plate 3. o; Plate 4.s) **(c)Tactic defecation-** Tactic defecation was found only in case of greater Indian rhinoceros. They communally defecated in a specific location. Defecation was done in such a way that it formed dung heaps. During defecation, the rhino pointed the hinder body towards dung heap and push the body and defected which formed a heap. This behaviour of rhino creates opportunity to the poacher to kill the rhino. Hedging by legs was found in the dung heap after defecation where, the rhino pushes the dung backward towards the dung heap (Plate- 3.q). **(d)Urination-** Urination was found in different postures. The male rhino urinated by facing the urogenital organ directly to the ground. Again, they also found to urinate in a backward direction pointing the urogenital organ towards the back from the middle of the two legs. However, the female squirted urine in the backward direction.

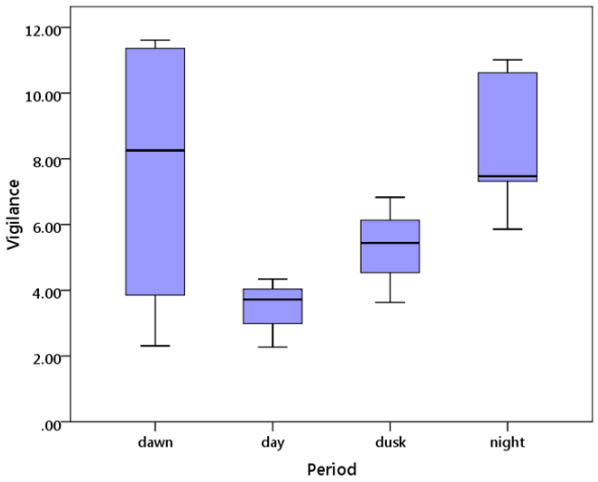


(a) Feeding

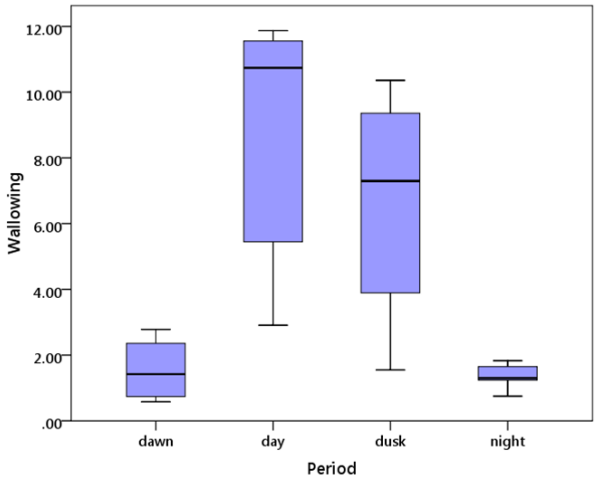


(b) Locomotion

Figure 3.1. Box plot shows the different activity rates **(a)** Feeding, **(b)** Locomotion, of *Rhinoceros unicornis* during day, dawn, dusk and night hours.

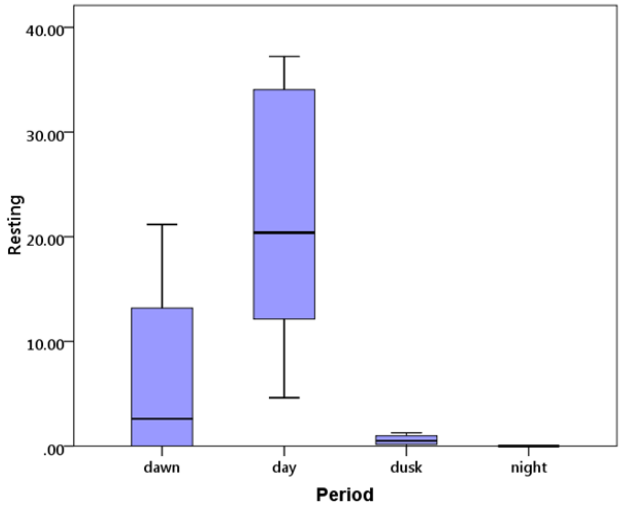


(c) Vigilance

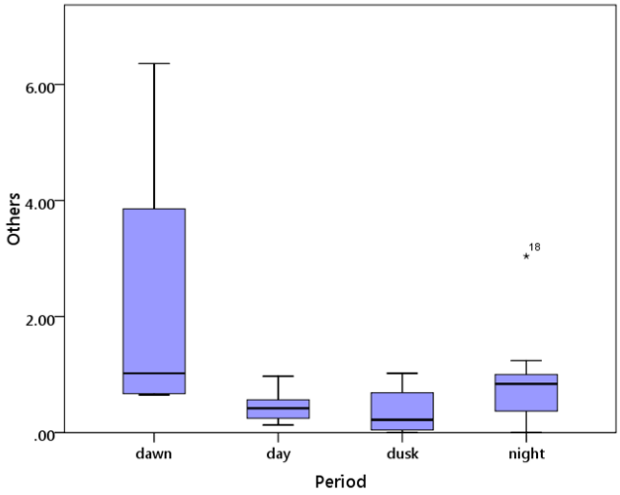


(d) Resting

Figure 3.2: Box plot shows the different activity rates **(c)** Vigilance, **(d)** Resting (night resting was not observed) of *R. unicornis* in the day, dawn, dusk and night hours.



(e) Wallowing



(f) Miscellaneous behaviour

Figure 3.3: Box plot shows the different activity rates (**e)** Wallowing (**f**) Other Miscellaneous behavior of *R. unicornis* in the day, dawn, dusk and night time periods.

Table 2. Breeding behavior and their description

Behaviour	Description
Pre- Mating behaviour	
Stare and approach	The rhino paused its existing activity and stare on the other, thereafter the individual moves toward or approach the opposite sex. It may be initiated by either of the sex.
Follow	The male individual followed any female and it was observed that as the male approaches, the female walked away. This type of behaviour was seen when the female showed no interest against the male approach. During that period both walked for a long distance.
Charge and Chase	The male was seen to charge suddenly or rushes towards the female and break into run behind, if the female runs away during the approach of the male. This happens if either the female is not in the estrus cycle or it fears the male. This type of running behind one another is called chasing. Chasing was observed to lasts for many hours with frequent breaks with rest and was found to cover many kilometers. They were also seen to go for wallow occasionally within break periods (Plate-4. w).
Lie together	On the acceptance of the approach by the opposite sex, both male and female were seen to lie together side by side and remained with each other for many hours prior to mounting. During this time, they remained closer to each other. If wallowing took place within that period, both were found to wallow nearby.
Nuzzling	Nuzzling is the contact of nose to nose. It was found that during the pre-mating period, both the male and female keep once nose in contact with the other and remain in that posture for few minutes.
Mutual-Body Rubbing	Mutual body rubbing is another type of pre-mating behavioural pattern which was found in Indian Rhino in the study area. During that behavioural posture, both male and female rubbed each other's body before mounting.
Body Licking and biting	Body licking of the male-female was found to be common during pre-mating behaviour. Body licking occurs specially in the head portion. However, licking in other region of the body was also observed. Licking was done by their prehensile lips and tongue. They also bite each other smoothly during this process (Plate-4. u).
Sparing	Both the male and female great Indian rhinoceros kept each other's horns in contact for some time. Contact of horn to horn between con-specific is known as sparing. Sparing during pre-mating period was not observed as offensive or defensive behaviour. It was seen after the acceptance of either sex.
Chin resting	Resting the chin of an individual rhino in the head portion of opposite sex was also found during pre-mating period. This behaviour was occasionally seen during the study period (Plate 4. v).
Urine-squirting	Urine-squirt behaviour of female rhino was seen common during pre-mating period. During this process the rhino projected the urine to the posterior side through the gap between two hind legs. The urine helps the male to determine the estrus status of the female.
Vocalization	Different type of vocalization was found during mating. The great Indian rhinoceros was found to roar during chasing and following another rhino. A whistling type sound was heard when the male dominated the female or after the submission of the female.
Sniffing	The male rhino sniffing the urogenital organ of the female Rhino or the vice versa was found during the pre-mating period.
Flehmen	The male raises the head, curls the upper lip and then rests the head on the back of female rhino (Plate 4. x).
Mating	
Mounting	Mounting is the process in which, the male ride on females back keeping his forelegs on her rump for the purpose of copulation and ejaculation. Mounting was observed to be continued more than an hour (Plate 4. t)
Dragging	While mounting, it was observed that the female carries the male on her back and the male generally could not walk properly with their two hind legs. During this process, when the female moves or walks, the male was found unable to walk properly and thus dragged by the female through the substratum.
Post-Mating	
	No such specific behavior was observed after mating. They continue their normal activities within a reach viz., feeding, locomotion, wallowing etc.

Table 3. Mean hourly activity patterns of *Rhinoceros unicornis* during 24 hours (day and night) time period in the study area (data were taken for 24-hour time period of rhino in the study area by aiding Night Camera trap data; na = data was not available).

Behaviours	Hours											
	6.00-7.00	**7.00-8.00**	**8.00-9.00**	**9.00-10.00**	**10.00-11.00**	**11.00-12.00**	**12.00-13.00**	**13.00-1400**	**14.00-15.00**	**15.00-16.00**	**16.00-17.00**	**17.00-18.00**
Feeding	55.49	49.1	45.63	52.66	51.52	59.23	66.69	64.76	76.37	78.16	79.59	74.61
Locomotion	30.06	22.07	11.00	04.47	03.26	05.87	05.47	07.24	04.17	08.83	05.25	10.36
Vigilance	02.31	05.40	2.27	04.23	03.72	02.51	03.46	04.34	03.84	05.44	05.44	03.63
Resting	05.20	21.18	37.22	33.21	034.9	20.39	12.51	11.77	04.62	00.32	01.27	00.69
Wallowing	00.58	00.9	02.91	04.83	06.07	11.87	11.64	11.47	10.74	06.23	08.36	10.36
Others	06.36	01.35	00.97	00.6	00.53	00.13	00.23	00.42	00.26	01.02	00.09	00.35
	18.00-19.00	**19.00-20.00**	**20.00-21.00**	**21.00-22.00**	**22.00-23.00**	**23.00-24.00**	**24.00-1.00**	**1.00-2.00**	**2.00-3.00**	**3.00-4.00**	**4.00-5.00**	**5.00-6.00**
Feeding	62.73	64.12	62.34	58.22	58.05	56.85	54.47	53.91	50.52	55.96	50.69	53.55
Locomotion	28.88	26.58	29.71	30.14	32.21	33.20	35.37	34.35	34.90	30.28	34.72	32.26
Vigilance	06.83	06.64	05.86	10.62	08.61	07.47	07.32	07.39	10.94	11.01	11.11	11.61
Resting	na	na	na	na	na	na	na	na	na	na	na	na
Wallowing	01.55	01.66	01.26	01.03	00.75	01.24	02.44	01.30	03.65	01.83	02.78	01.94
Others	00.00	01.00	00.84	00.00	00.37	01.24	00.41	03.04	00.00	00.92	00.69	00.65

The feeding activity reached peak in the month of February (65.85±16.29), decreased towards August (45.55±16.34) and again gradually increased and reached the second peak in December (65.43±17.89; Table 5). Wallowing was found to be highest in July (24.73±19.91) and lowest in March (3.13±6.70; Table 5). Locomotion was found highest in February (13.65±3.45) and lowest in March (5.11±4.34; Table 5). Moreover, resting was found to be more in December (6.19±5.23) and least in May (1.19±1.14; Table 5). One-way ANOVA showed significant variation in feeding ($F_{11,172}$=2.554, p=0.005), wallowing ($F_{11,172}$=5.748, p=0.000), locomotion ($F_{11,172}$=5.345, p=0.000) and resting ($F_{11,172}$=3.871, p=0.000).

The time spent in feeding at day time was found maximum in winter (64.19±15.00), followed by pre-monsoon (59.08±12.73) and re-treating monsoon (59.88±2.77) and declined towards monsoon (51.67±10.87; Table 6; Figure 4). Locomotion was found higher during winter (11.34±5.80), followed by retreating monsoon (9.96±3.68), monsoon (6.58±6.26) and pre-monsoon (6.58±6.23; Table 6; Figure 4). On the other hand, the resting behaviour reached the peak during pre-monsoon (19.91±16.53) followed by monsoon (18.55±12.62), retreating-monsoon (13.46±5.77) and winter (12.18±13.30; Table 6; Figure 4). Whereas wallowing was most prevalent during monsoon (18.75±14.69) and lowest in winter (6.02±10.35; Table 6; Figure 4). One-way ANOVA among the seasons showed significant variation in feeding ($F_{3,180}$=6.595, p=0.000), locomotion ($F_{3,180}$= 13.347, p=0.000), resting ($F_{3,180}$=4.025, p=0.008) and wallowing ($F_{3,180}$=6.98, p=0.000).

Age-sex variations of activity budget

The overall age-sex class wise studies on diurnal activity pattern of rhino showed that, the feeding activity was highest in female (mean % ±SD: 62.01±13.27) followed by male (59.65±11.23), sub-adult (59.66 ±17.71) and calf (55.98 ±13.77; Table 7; Figure 5). Again, locomotion was found to be highest in male (10.00±6.70), followed by calf (8.00±6.44), sub-adult (7.93±5.36) and female (7.40±4.76; Table 7; Figure 5).Vigilance was tend to be highest in males (4.98±4.13) than calves (4.61±3.51), female (3.90±3.10) and sub-adult (3.90±3.03; Table 7; Figure 5), whereas, resting was found to be more in case of calf (22.78±16.65) followed by female (17.66±13.60), sub-adult (15.81±16.26) and male (10.96±11.12; Table 7; Figure 5). However, the wallowing activity was highest in male (13.05±13.28) followed by Sub-adult (11.78±16.66), female (8.16±12.57) and calves (7.84±10.67; Table 7; Figure 5). Group-wise analysis using Independent T-test between male and female showed significant difference with locomotion (t_{132} =2.601, p=0.01), resting (t_{132} = -3.098, p=0.002) and wallowing (t_{132}=2.190, p=0.03). Whereas male and calf showed significant variation in resting (t_{94}=-4.144, p=0.00), wallowing (t_{94}=1.946, p=0.050) and other activities (t_{94}=2.648, p=0.009). However, female and calf showed significant variation with feeding (t_{102}=2.130, p=0.036) and other activities (t_{102}=2.492, p=0.014).

Difference in activity budgets between single females and females with calf was also found. In females with calf, feeding (62.68±13.70), resting (18.38±14.49), and wallowing (9.58±14.13) behaviours were found to be higher than the single females (Feeding-61.39±13.03, resting-17.01±12.89, wallowing-6.84±10.97; Table 8; Figure 6). Whereas, locomotion, vigilance and other

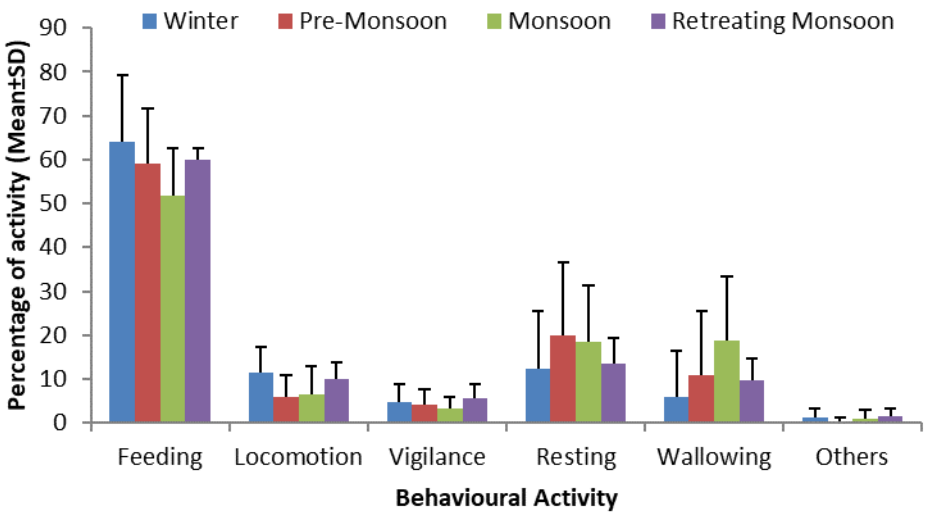


Figure 4. Mean percentage of activity pattern of *Rhinoceros unicornis* in different seasons of the year (data was represented as percentage basis).

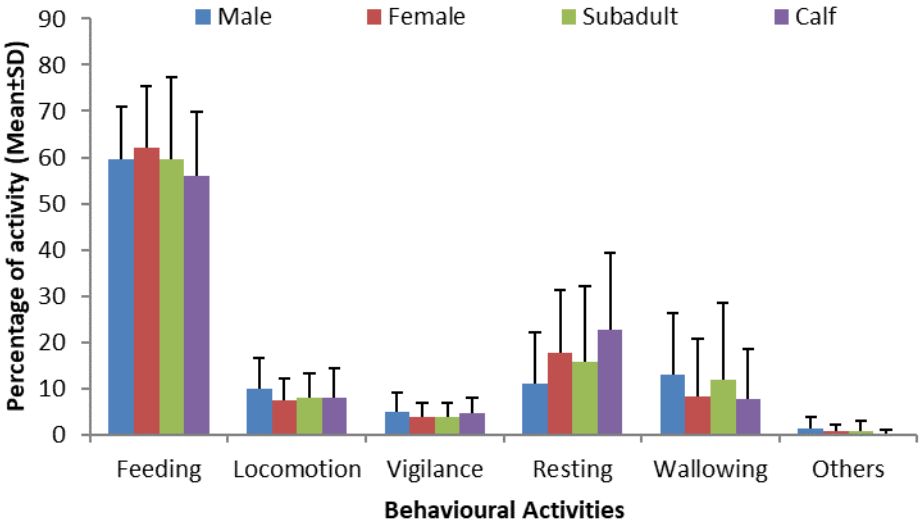


Figure 5. Mean percentage of different activity patterns amongst different age and sex groups of *Rhinoceros unicornis* in KNP.

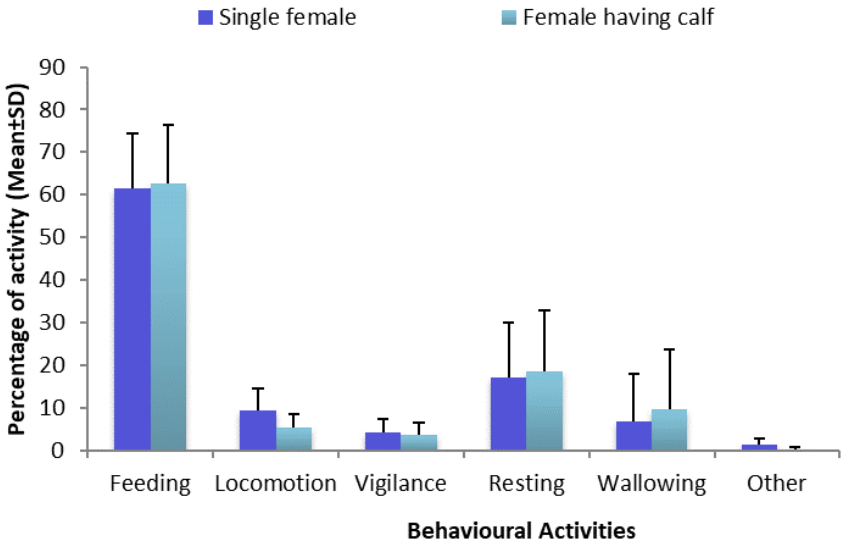


Figure 6. Mean percentage of activity pattern of single females and females with calf in the study area.

Table 4. Mean percentage of activity in different periods within 24 hours of *Rhinoceros unicornis* in KNP (data was represented as mean ±SD)

Period	Activity (in % basis)						
	Feeding	Locomotion	Vigilance	Resting	Wallowing	Others	Total Scans
Dawn	52.20±2.85	29.77±5.47	07.60±4.51	06.59±10.00	01.55±01.00	02.26±2.75	694
Day	59.55±10.54	05.92±2.58	03.48±0.80	22.08±13.05	08.50±03.77	00.44±0.28	8899
Dusk	73.77±7.65	13.33±10.58	05.33±1.31	00.57±00.54	06.62±03.78	00.36±0.46	3199
Night	57.16±4.19	31.86±2.90	08.42±1.96	0	01.35±00.33	00.86±1.32	2226
F-value	F=7.109*	F=39.899**	F=7.051*	F=11.019**	F=12.772**	F=2.175 ^{ns}	

**Significance level: p<0.01; *Significance level: p<0.05; ^{ns} Not significant

Table 5. Mean monthly variation of activity patterns of *Rhinoceros unicornis* in KNP (data was represented as a percentage of time spent in each type of activity).

Month	Activity pattern (in% basis)						
	Feeding	Locomotion	Vigilance	Resting	Wallowing	Others	Total Scans
January	62.39±12.39	11.23±07.10	16.38±13.25	04.30±2.69	04.28±7.15	01.38±2.80	2411
February	65.85±16.29	13.65±03.45	09.39±15.40	04.43±3.71	05.44±08.39	01.21±1.94	1090
March	61.33±12.87	05.11±04.34	25.97±15.40	04.22±4.03	03.13±06.70	00.22±0.58	2871
April	57.50±12.82	06.78±05.74	12.45±16.52	04.22±3.28	18.46±17.33	00.57±0.80	2113
May	51.75±08.18	05.84±05.92	17.86±03.90	01.19±1.14	22.54±14.21	00.79±1.29	305
June	58.16±03.78	05.29±02.31	17.23±08.49	02.2±0.80	15.68±11.73	00.98±1.52	385
July	49.97±09.97	09.03±12.19	11.18±10.81	03.71±4.10	24.73±19.91	01.35±2.11	131
August	45.55±16.34	02.87±02.26	28.56±17.06	02.01±1.49	19.96±19.50	01.04±2.94	456
September	54.18±04.35	09.40±01.84	15.05±03.42	05.11±1.27	15.36±04.15	00.87±1.11	589
October	58.72±02.25	09.07±02.53	13.42±04.80	05.09±2.14	12.46±04.60	01.21±1.41	422
November	60.53±02.90	10.46±04.20	13.48±06.44	05.97±3.70	08.02±04.36	01.50±2.28	591
December	65.43±17.89	09.08±04.55	08.09±08.85	06.19±5.23	09.52±15.35	00.65±1.17	807
Mean (year)	60.22±10.49	06.58±03.13	03.67±01.55	13.21±7.27	15.70±13.33	00.62±0.59	**12171**
F-value	F=6.595**	F=13.347**	F=2.501^{ns}	F=4.025*	F=6.982**	F=2.857*	

**Significance level: p<0.01; *Significance level p<0.05; ^{ns} Not significant

Table 6. Mean percentage of time spent in different activities in different seasons of the year in the study area (data was represented as mean ±SD)

Season	Activity (in % basis)						
	Feeding	Locomotion	Vigilance	Resting	Wallowing	Others	Total Scans
Winter	64.19±15.00	11.34±05.80	04.85±03.83	12.18±13.30	06.02±10.35	01.14±2.22	4308
Pre-Monsoon	59.08±12.73	05.84±05.05	03.99±03.65	19.91±16.53	10.76±14.81	00.41±0.75	5289
Monsoon	51.67±10.87	06.58±06.23	03.30±02.45	18.55±12.62	18.75±14.69	01.05±01.96	1561
Retreating Monsoon	59.88±02.77	09.96±03.68	05.66±03.20	13.46±05.77	09.64±04.86	01.4±01.97	1013
F-value	F=6.595**	F=13.347**	F=2.501^{ns}	F=4.025*	F=6.982**	F=2.857*	

**Significance level: p<0.01; *Significance level: p<0.05; ^{ns} Not significant

activities were higher in single female (locomotion: 9.21±5.29, vigilance: 4.25±3.17 and others: 1.38±1.41; Table 8; Figure 6) than female with calf (locomotion: 5.44±3.12, vigilance: 3.52±3.03 and others: 0.17±0.58). Analysis using independent T-test between female and female with calf showed significant variation with locomotion (t_{69} =3.614, p=0.001) and other activities (t_{69}, p=0.000).

Night Activity budget

Study found that, the great Indian rhinoceros showed all the prime behaviours viz., feeding, locomotion, vigilance, wallowing and other miscellaneous activities including breeding behaviour and aggression during night time. During present nocturnal behavioural studies, the feeding occurrences were found to be highest in the month of May (71.20±1.92) and lowest in February (52.01±1.93; Table 9; Figure 7). Whereas, locomotion was, found to be higher in February (37.84±15.83) and lower in December (28.71±17.30; Table 9; Figure 7). However, wallowing was found higher in January (2.19±1.55), February (2.71±3.40) and May (2.06±2.94), whereas, lower in December (1.02±2.04), March (1.47±1.06) and April (1.78±3.26; Table 9; Figure 7). Moreover, vigilance was found to be higher in April (11.86±5.88) and lower in May (4.11±3.24 Table 9; Figure 7). And other activities were found highest in the month of December (2.72±3.18; Table 9; Figure 7). One Way ANOVA amongst the months showed significant variation in feeding ($F_{5,66}$=18.09,p=0.000), locomotion ($F_{5,66}$= 29.65, p=0.000), wallowing ($F_{5,66}$=5.80, p=0.000), vigilance ($F_{5,66}$= 10.30, p=0.000) and other activities ($F_{5,66}$= 2.39, p=0.047).

Table 7. Mean percentage of activity pattern of *Rhinoceros unicornis* in different age and sex classes during day and night hours (**na**: Resting data was not available for night activity; Values were given in mean ±SD)

	Male		Female		Sub-adult		Calf	
	Day	Night	Day	Night	Day	Night	Day	Night
Feeding	59.65±11.23	56.15±04.55	62.01±13.27	57.2±04.51	59.66±17.71	54.88±25.76	55.98±13.77	63.30±09.40
Locomotion	10.00±06.70	33.04±03.53	07.40±04.76	31.23±05.74	07.93±05.36	34.84±21.13	08.00±06.44	26.51±08.67
Vigilance	04.98±04.13	07.80±01.45	03.90±03.10	07.70±02.44	03.90±03.03	07.87±07.79	04.61±03.51	08.33±03.22
Resting	10.96±11.12	**na**	17.66±13.60	**na**	15.81±16.26	**na**	22.78±16.65	**na**
Wallowing	13.05±13.28	1.31±1.37	08.16±12.57	01.94±01.31	11.78±16.66	02.39±03.72	07.84±10.67	01.85±02.52
Total scans	4833	1220	4474	1196	793	63	2062	344

Table 8. Mean percentage of activity pattern of *Rhinoceros unicornis* in female and female with calf

	Activity %						Total scan
	Feeding	Locomotion	Vigilance	Resting	Wallowing	Others	
Female	61.39±13.03	09.21±05.29	04.25±03.17	17.01±12.89	06.84±10.97	01.38±01.41	2383
Female having calf	62.68±13.70	05.44±03.12	03.52±03.03	18.38±14.49	09.58±14.13	00.17±00.58	2091

Table 9. Mean Percentage of night time observation of behavioural activity budgeting of *Rhinoceros unicornis* in different months of the year in the study area (data was represented as mean ±SD).

Month	Feeding	Locomotion	Vigilance	Wallowing	Others	Total Scans
December	60.42±01.44	28.71±17.30	07.11±05.18	01.02±2.04	02.72±03.18	107
January	57.38±04.34	30.68±04.03	08.82±03.03	02.19±1.55	00.91±01.09	629
February	52.01±01.93	37.84±15.83	07.01±01.26	02.71±3.40	00.42±00.62	679
March	53.61±02.96	35.89±03.51	08.65±02.35	01.47±1.06	00.36±00.42	638
April	52.67±08.53	33.67±02.78	11.86±05.88	01.78±3.26	0	559
May	71.20±01.92	37.84±15.83	04.11±03.24	2.06±2.94	00.96±01.11	235
F-value	F=18.09**	F=29.65**	F=10.30**	F=5.80**	F=2.39*	
**Significance level: p<0.01; *Significance level: p<0.05						

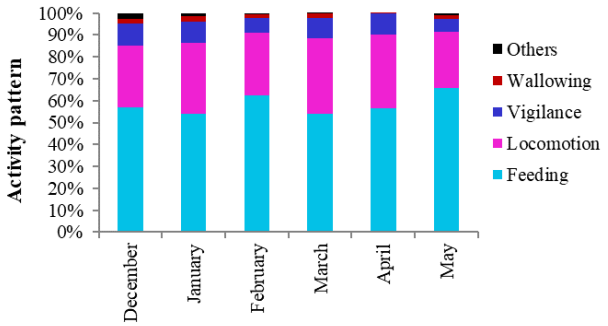


Figure 7. Figure shows the mean percentage of night activity studies in different months in the study area.

The night time behavioural study of age-sex groups of rhino in KNP showed that, the feeding activity was highest in calf (63.30±9.40) followed by female (57.2±4.51), male (56.15±4.55) and sub-adult (54.88±25.76; Table 7), whereas, locomotion was found to be highest in sub-adult (34.84±21.13) followed by male (33.04±3.53), female (31.23±5.74) and calf (26.51±8.67; Table 7). However, vigilance was almost similar among adults and sub-adults (male-7.80±1.45, female-7.70±2.44, sub-adult-7.87±7.79) and higher in calves (8.33±3.22; Table 8). Again, wallowing was found to be higher in sub-adult (2.39±3.72) and almost similar in other age/sex classes (male-1.31±1.37, female-1.94±1.31, and calf-1.85±2.52; Table 7). Feeding was found to be the highest during day time followed by night time in all the classes. Whereas, the locomotion and vigilance were found to be more during night hours than day hours. Again, wallowing was higher during day time compared to night time (Table 7).

Effect of environmental factors on activities

Analysis of Pearson correlation of diurnal behavioural activities with environmental parameters **viz**., temperature, humidity, cloud covers and rainfall showed that, there was significant negative correlation of feeding behaviour with temperature (r = -.310, N=184, p<0.01), humidity (r = -.234, N=184,p<0.01) and rainfall (r = -0.305, N=184, p<0.01), cloud cover (r = -0.188, N=184, p<0.05) in which the feeding behaviour tend to be declined in increasing temperature, humidity, rainfall and cloud cover (Figure 8.1). Again, locomotion also showed significant negative correlation with temperature (r = -0.323, N=184, p<0.01), humidity (r = -7; N=184, p<0.01; Figure 8.2). In contrary, resting showed moderate positive correlation with temperature (r =0 .132, N=184, p>0.05) and rainfall (r = -0.053, N=184, p>0.05), whereas, it was negatively correlated with humidity (r = -.012, N=184, p>0.05) and cloud covers (r = -.019, N=184, p>0.05). Again, wallowing showed significant positive correlation with all the environmental factors **viz**., temperature (r = .381, N=184, p<0.01), humidity (r = .345, N=184, p<0.01), rainfall (r = 0.384, N=184, p<0.01) and cloud covers (r = 0.317, N=184, p<0.01; Table 10; Figure 8.3). Analysis of Pearson correlation of night time behaviour with environmental factors showed negative correlation of feeding behaviour with temperature (r = -0.077, N=72, p>0.05) and humidity (r = -0.582, N=72, p<0.01; Fig 8.4d) while, showed positive correlation with rainfall

Table 10. Pearson Correlation of different diurnal activities with temperature, humidity, rainfall and cloud covers.

Activities	Statistics used	Temperature	Humidity	Rainfall	Cloud
Feeding	Pearson Correlation	-00.31**	-00.23**	-00.31**	0.19*
Locomotion	Pearson Correlation	-00.32**	-00.23**	-00.20**	-0.23**
Vigilance	Pearson Correlation	-00.18*	00.01	-00.14*	00.01
Resting	Pearson Correlation	00.13	-00.01	00.053	-00.02
Wallowing	Pearson Correlation	00.4**	00.35**	00.38**	00.32**
Others (Misc.)	Pearson Correlation	-00.10	-00.01	00.01	-00.05

** Correlation is significant at 0.01 level (2-tailed); * Correlation is significant at 0.05 level (2-tailed).

Table 11. Pearson Correlation of different night activities with temperature, humidity and rainfall in the study area.

Activities	Statistics use	Temperature	Humidity	Rainfall
Feeding	Pearson Correlation	-00.10	-00.60**	0.04
Locomotion	Pearson Correlation	-00.12	-00.50**	00.10
Wallowing	Pearson Correlation	-00.26*	-00.40**	-00.10*
Vigilance	Pearson Correlation	-00.14	-00.35**	00.05
Others	Pearson Correlation	-00.30*	-00.27*	-00.31**

**. Correlation is significant at 0.01 level (2-tailed); *. Correlation is significant at 0.05 level (2-tailed).

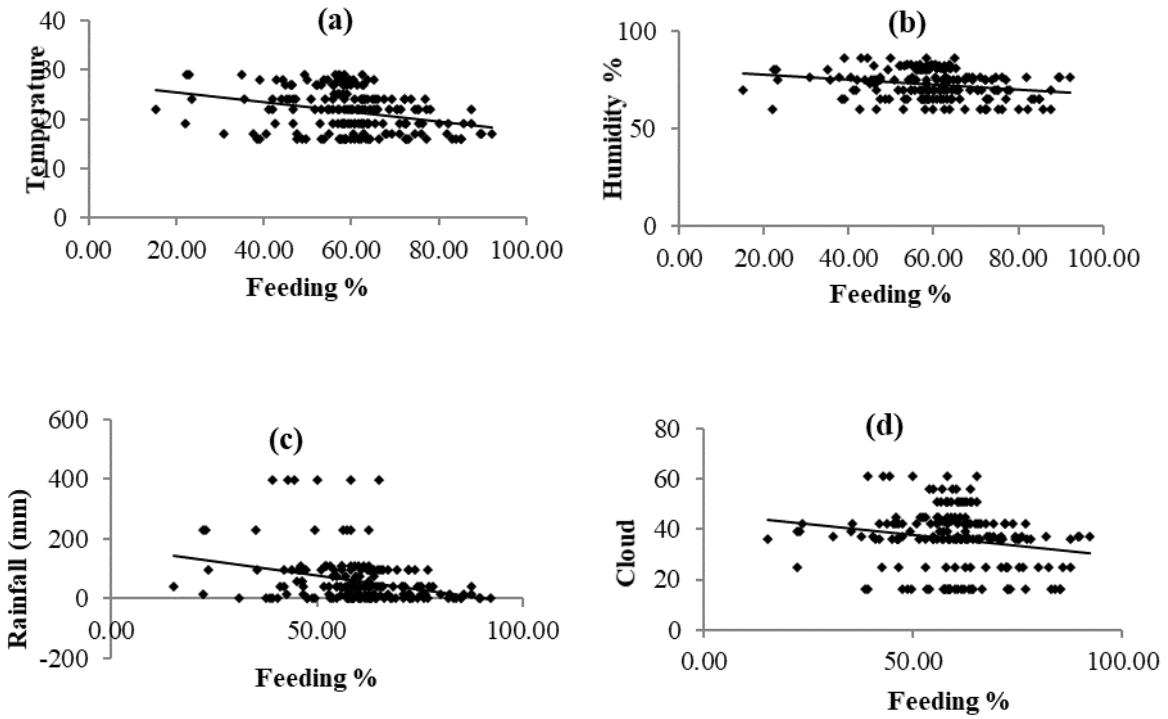


Figure 8.1. Correlation of mean feeding percentage with (a) Temperature, (b) Humidity, (c) Rainfall and (d) Cloud cover of *R. unicornis* in KNP.

(r = 0.044, N=72, p>0.05). Again, wallowing showed moderate significant negative correlation with temperature (r = -0.256, N=72, p<0.05), rainfall (r = -0.282, N= 72, p<0.05) and humidity (r = -0.402, N=72, p<0.01; Figure 8.4a-c). Study also showed highly significant negative correlation of locomotion and vigilance behaviour with humidity (locomotion: r = -0.483, N=72, p<0.01; vigilance: r = -0.384, N=72, p<0.01). The, other behavioural activities of rhino during night time period showed moderate significant negative correlation with temperature (r = -0.289, N=72, p<0.05), humidity (r = -0.269, N=72, p<0.05) and rainfall (r = -0.307, N= 72, p<0.01; Table 11).

DISCUSSION

There are six non-breeding behaviours found to be present in the great Indian rhinoceros. The unique behaviour of heap defecation was renamed as tactic defecation. The behavioural postures found are similar to that of Laurie (1978) and Hazarika & Saikia (2010). The breeding behaviours are found to have thirteen pre-mating and two mating postures, in which stare & approach, follow, charge & chase and sniffing are newly coined. The mating behavioural postures were similar to that of Stoops *et al*. (2014) except the newly coined.

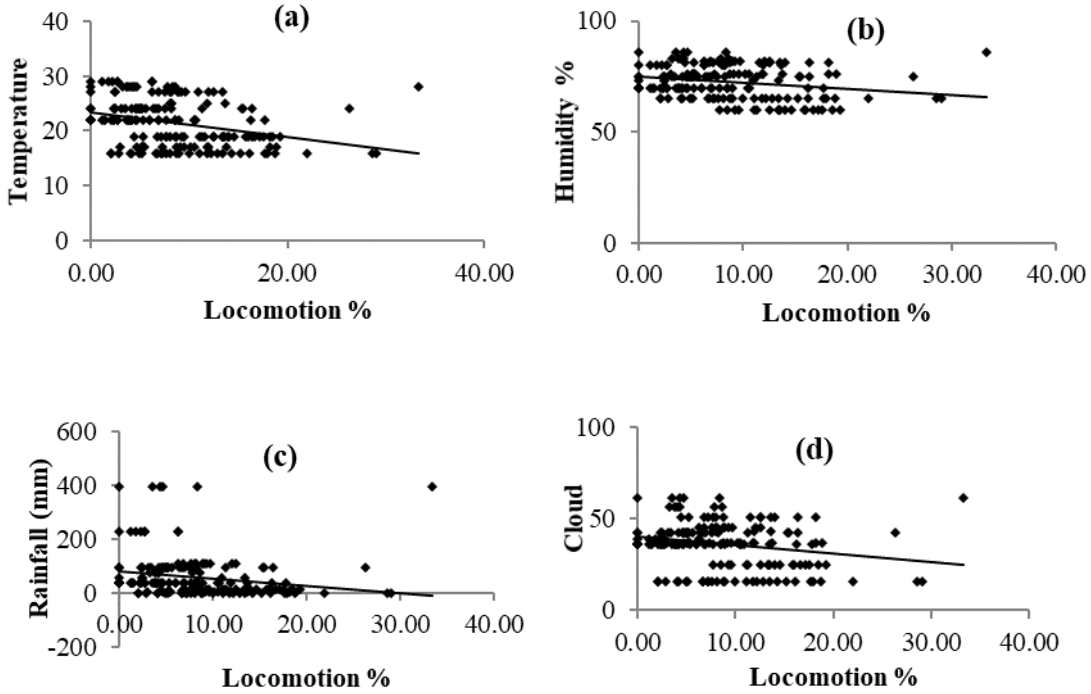


Figure 8.2. Correlation of mean locomotion percentage with (a) Temperature, (b) Humidity, (c) Rainfall and (d) Cloud cover of *R. unicornis* in KNP.

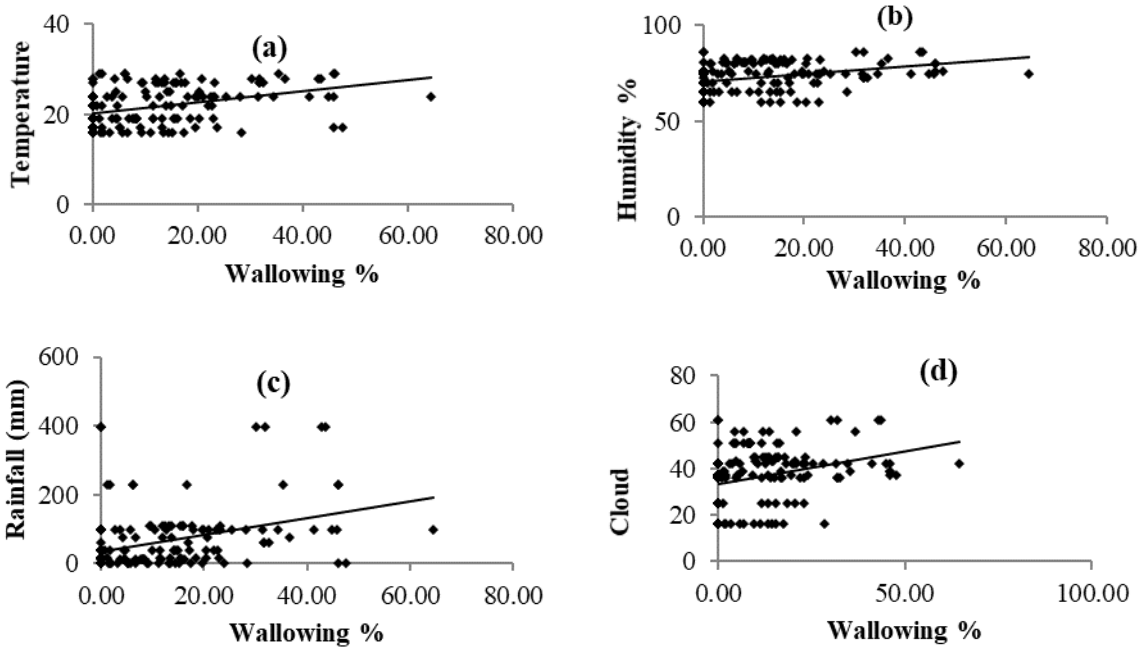


Figure 8.3. Correlation of mean wallowing percentage with (a) Temperature, (b) Humidity, (c) Rainfall and (d) Cloud cover of *R. unicornis* in KNP

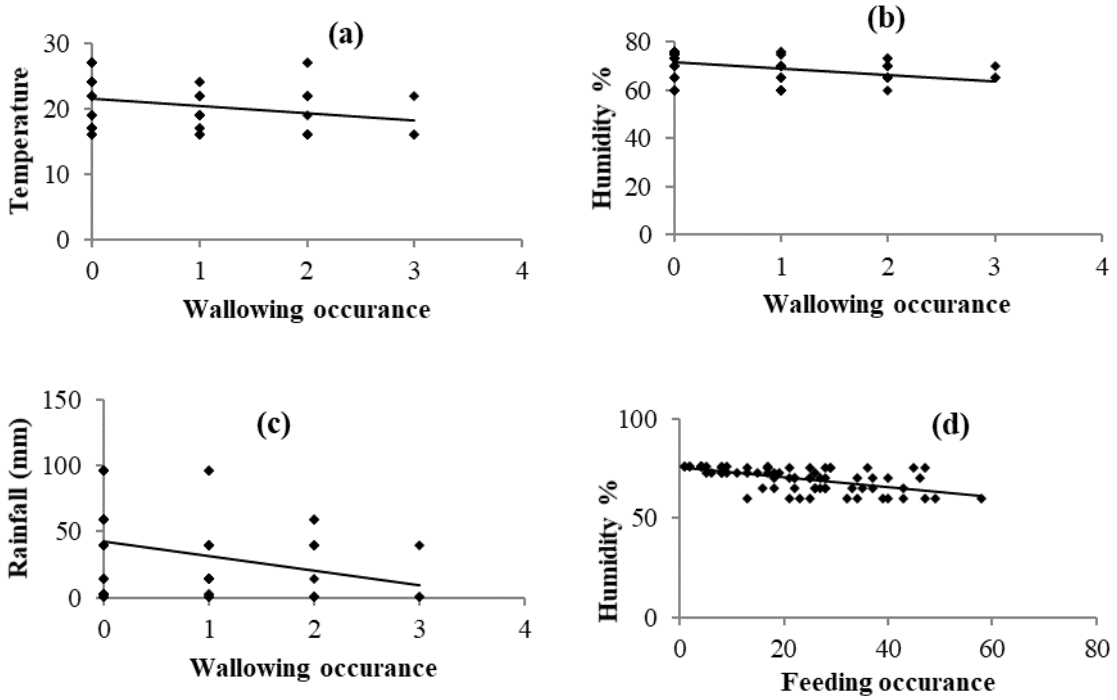


Figure 8.4. Correlation of mean night wallowing percentage with (a) Temperature, (b) Humidity, (c) Rainfall and mean night feeding with humidity of *R. unicornis* in KNP

Study opined that, feeding is the dominant activity performed by the great Indian rhinoceros. The maximum time investment in feeding indicates the high demands of food requirements of the species to maintain their huge body size and other lively activities. Rhinoceros are hindgut fermenter and have the ability to digest faster as per Owen-Smith (1988), than the other larger herbivorous animal, hence, more food is required for their body. Another reason behind the investment of higher time in feeding activity is the grazing pattern, in which, only little amount is engulfed per bites avoiding the root parts. Laurie (1978) and Hazarika & Saikia (2010) have also suggested similar kinds of findings. Similarly, several studies on other mega herbivores like black rhino (Joubert & Eloff, 1971), white rhino (Jordan, 2010), wild elephant (McKay, 1973; Vancuylenberg, 1977; Saikia, 2012) and swamp deer (Ahmed & Khan, 2014) also suggests higher time investment in feeding activity.

The proportion of overall activity pattern changes along with the changes of environmental factors, months, seasons and change in the quality of food across the year. Variation of feeding behaviour is also significant amongst different age/sex classes. Clutton-Brock & Harvey (1977) have also found that, the proportions of feeding activity in primates, changes according to the availability of food as well as prevailing ecological factors throughout the year. The present study reveals that, feeding activity increases in winter season and declines in the monsoon season, which indicates that, nutritional value of food does not remain same throughout the year. Again, the mega herbivores never try to compensate the adverse situation and potentially try to maintain the balance of calorie and nutrient requirement, either by increasing the bite size or by increasing the time allocation in feeding activity. This situation was supported by several workers of mega herbivorous species across the globe (Spalinger *et al.,* 1988; Laca *et al.*, 1994; Illius & Gordon, 1992). According to Shrader *et al.* (2006), with the decrease of greenness of grasses, the crude protein, phosphorus, sodium declines, whereas, in the progress of pre-monsoon with the initiation of the rain, it again increases. This observation is also supported by the negative correlation of rainfall and temperature with feeding activity during the present study. Hazarika *et al.* (2013) have reported higher feeding activity during winter season in Rajib Gandhi Orang NP. In contrary, Dutta & Mahanta (2016) have reported higher feeding activity in monsoon and lower in winter at Manas National Park. The finding of feeding peak at dawn and dusk with a mid-day peak of wallowing and resting behaviours of Great Indian Rhinoceros indicates the behavioural adaptation towards differences against the temporal variation of environmental gradient of temperature. Similar types of results were also found by Clutton- Brock (1977) in case of studies on primates.

Coprophagy in great Indian rhinoceros' calves was evident during the present study. It helps the calf to mature their digestive system with required gut microbes. It was also observed in elephant calf during the study period. However, the elephant calf ingested the dung of another sub-adult of the herd. Moreover, according to Hornicke & Bjornhag (1980) and Stillings & Hackler (1966), coprophagy increases during the period of higher nutrient requirement. Coprophagy behavior is also reported in white rhino (Du Toit, 1998), rodents (Hagen *et al.*, 2015; Kenagy & Hoyt, 1979) and rabbits (Ebino *et al.*, 1993).

Increase feeding activity is always associated with increase time investment in locomotion to achieve their required food in the habitat that is evident in present study. Locomotion of Rhinoceros is highest in winter season and decreases in monsoon and pre-monsoon. In contrary, Dutta & Mahanta (2016) have reported higher locomotion activity of translocated great Indian rhinoceros in monsoon and lower in winter season. Requirement of more time investment in feeding activity is the

possible reason for the increasing locomotion activity in winter season.

Wallowing is considered another important activity performed as the strategy for thermoregulation in response to increased temperature and to get rid of external parasites. Ghose (1991) also suggested that, apart from increase in temperature, wallowing is also found to get rid from flies, ticks and other ectoparasites. Tanaka & Tanaka (1982) have reported that, the number of insects and flies increases in the monsoon season and are less during winter season with the change in rainfall and temperature. The great Indian rhinoceros in KNP either go for mud wallowing or wallow in the water bodies whatever is available in their home range. Wallowing was mostly found in the beels and *ghulis* (small water-puddles in the grasslands). However, occasionally wallowing was also found in lotic water bodies **viz.**, the *nallas* (small steam) and Diffolu river of Kaziranga NP. Study found that, wallowing reaches the peak in the monsoon season and decline in the winter season. Hazarika *et al*. (2013), Laurie (1982), Dinerstein (2003), Janwali (1995) and Dutta & Mahanta (2016) have also reported similar findings. The present study found positive correlation of wallowing with rainfall. Hazarika *et al*. (2013) and Dutta & Mahanta (2016) have also suggested similar findings of heavy rainfall. This is happened due to increasing humidity before and after rain that leads to increases atmospheric temperature.

Present study reveals that, resting is highest in pre-monsoon and analysis showed that, resting activity is positively correlated with temperature and rainfall. The increase in resting behaviour during pre-monsoon is mainly due to surplus of time because they need to invest less time for feeding owing to availability of more nutritious food. In contrary Hazarika *et al*. (2013) reported higher resting behaviour in retreating-monsoon. Vigilance is another important activity performed by the great Indian rhinoceros as it performed as a result of existence of any enemy/ foreign object or other individuals. KNP experiences large numbers of national and foreign tourist that starts from retreating monsoon in the park. Even in the core areas, the entry of the officials increases. Hence, the vigilance activity increases in the retreating monsoon. However, vigilance decreases in winter as rhino become used up of tourists and declines towards pre-monsoon owing to decrease of human interference. On the other hand, Hazarika *et al*. (2013) reported highest vigilance during pre-monsoon in Orang National Park. Vigilance was more during dawn, night and dusk as the rhino has poor eye sight and keep alert in absence of sunlight.

The rhinoceros has found to defecate at the same location in their habitat for longer period of time. This tendency of tactic defecation was also reported by Laurie (1978), although, occasional, rhino dung was also seen outside the dung heap during study.

Observing higher percentage of feeding activity by lone females and highest percentage of female with calf in the present study indicated that, the females have to pay more energy cost during pregnancy and as well as nourishing the calf. Again, studies on the behavioural activities on mega herbivore species like topi, red deer, giraffe and warthog also suggested higher feeding activity by females (Duncan, 1975; Clutton-Brock *et al.,* 1982; Leuthold & Leuthold, 1978; Clough & Hassam, 1970). However, the opposite was found in case of bushbuck (Apio, 2003; Apio & Wronski, 2005) and nubian ibex (Gross *et al.*, 1995) owing to habitat characteristics and variability of environmental factors. Locomotion was found to be highest among the male followed by calf. The adult bulls always use a larger territory (Laurie, 1978). Having larger territory and moving long distance in search of estrus female enhances the increase in locomotion activity. Calves are normally enthusiast and roam in and round their mother. Moreover, locomotion was found significantly low in case of females having calf than solitary females. Females having calf never move to longer distance for the sake of the calf and preferably remain in open area to save their calf from tiger predation. Moreover, they are less chased by the bulls. Again, the male rhinoceros showed higher wallowing activity followed by sub-adult. Spending more time in locomotion, increases body heat, which is preferably the reason for higher wallowing activity in males. Most remarkably, wallowing (by male) in between chasing the female for mating purpose was also recorded during the study period. While chasing, they run a long distance, hence to reduce the heat, they jump into the water, remain for some time and again continue chasing.

The diurnal resting activity was found to be higher in calf followed by females especially female with calf and then sub-adult and male. Calf devoted less time in other activities hence they adjust their time allocation by resting for longer period. Whereas, females tend to conserve energy for the nourishment of the calf and to give them company. Hence, they also have to devote more time in resting activity. Adult males spend much time in defending their territory and tracking the females (Dinerstein, 2003), hence they get less time for resting. However, the resting activity was found more in the day time compared to dawn and dusk due to higher temperature at day time.

The great Indian rhinoceros were found to be more or less active throughout the night. It is happening due to less environmental constraint and longer active period of the species within 24-hour's time period. Laurie (1978) and Hazarika *&* Saikia (2010) also indicated the night feeding behavior of rhinoceros in Nepal and Brahmaputra valley respectively. The highest night feeding activities of Rhinoceros during the month of May indicates the compensation of less day feeding activity in the month May to fulfill the daily food requirement of the species. Locomotion and wallowing were also found during the night time. However, Hazarika *et al*. (2013) reported that rhino never wallow at night probably they never used camera trapping tools. Night wallowing was found to be higher during winter season than pre-monsoon. The present study showed significant negative correlation of wallowing at night with temperature. This is preferably to get rid from extreme cold in the winter season as the water temperature remains higher than the atmospheric temperature at night time during winter. Increase active behaviours like feeding and locomotion at the night time makes the species vulnerable to the poachers and predators.

All rhinoceros species are polygamous and polyandrous as per Owen-Smith (2004). Generally, the male Rhino introduces the mating event by following the female and chasing as suggested by Laurie (1978) and Ripley (1952), but cases were also seen where the female induced the male during the present study. Hazarika and Asikis (2010) have also mentioned initiation of mating by females. This may be either because the female is in high estrus period or the previous copulation was not successful. Dominating bulls never allowed any other male when it finds an estrus female and aggression was

found during this period leading to sever injuries. In contrast, it was also found that a male while lying together with the female, left the female in the entry of another male and none of the males showed any aggressiveness against each other. Urine smell was found to be used as a tool by male Rhinoceros to track the females. The increased level of progesterone in the urine indicates the estrus in female Rhinoceros as suggested by Schwarzenberger *et al.* (2000). Exceptionally, a female with calf was found during the study that took the smell of the male urine and changed the track. It is probably to prevent her from the attempt of mating. However, detail study on the mating preference is necessary.

In conclusion, great Indian one horned rhinoceros depicts a marked circadian rhythm in the activity patterns, with a feeding peak at dawn and dusk and a prolonged wallowing and resting period in the day time. Winter season shows highest feeding investment due to low food nutritional value. Females tended to invest more time in feeding while males invested more time in locomotion and resting. Rhinoceros are active throughout the night having wallowing peaks at winter. Feeding and locomotion showed negative correlation and wallowing showed positive correlation with temperature and rainfall.

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Plate-1: Different types of feeding behaviour of *Rhinoceros unicornis* in KNP **(a)** Feeding in tall grassland, **(b)** Feeding in wetland, **(c)** Feeding in short grassland, **(d)** Drinking **(e)** Lactating and **(f)** Browsing behaviour in woodland habitat.

(a)

(b)

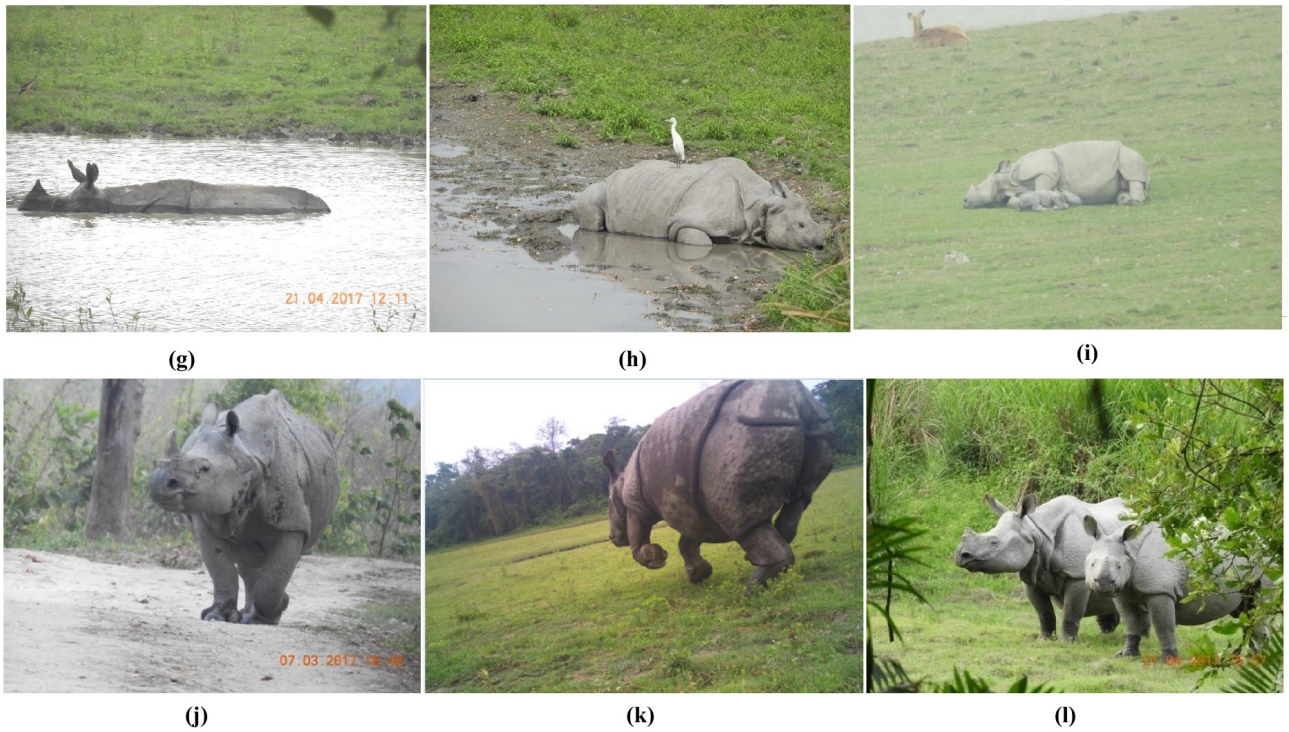
(c)

(d)

(e)

(f)

Plate-2. Different types of wallowing, comfort and locomotion behaviour of *Rhinoceros unicornis* in KNP **(g)** Wallowing, **(h)** Mud-wallowing, **(i)** Resting, **(j)** Walking, **(k)** Galloping, **(l)** Vigilance.



(g) **(h)** **(i)**

(j) **(k)** **(l)**

Plate-3. Behaviours observed during night time in KNP using Camera Traps**:(m)**Feeding at night, **(n)**Lactating at night, **(o)**Fighting at night, **(p)**Night wallowing sign, **(q)**Defecation, **(r)** Male performing urine smell (Source-

(m) **(n)** **(o)**

(p) **(q)** **(r)**

Plate-4. (s): Aggression, (t) :(Mating)-Mounting, **(u):** Rubbing and licking, **(v):** Chin rest, **(w):** Chasing, **(x):** Flehmen effect [Source: t, w & x was from Camera trapping, DFO office, Bokakhat, Assam].

(s) **(t)** **(u)**

(v) **(w)** **(x)**