ACTIVITY PATTERN AND TIME BUDGET ANALYSIS OF MANIPUR BROW-ANTLERED DEER *Rucervus eldii eldii* (M'CLELLAND, 1842) UNDER THE CONSERVATION BREEDING PROGRAMME IN NATIONAL ZOOLOGICAL PARK, DELHI, INDIA

Pratyansha Singh

[1]University School of Environment Management, Guru Gobind Singh Indraprastha University, Dwarka Sector 16C, Delhi, India

Amarjeet Kaur

University School of Environment Management and Centre for Disaster Management Studies, Guru Gobind Singh Indraprastha University, Dwarka Sector 16C, Delhi, India

Sumit Dookia

University School of Environment Management, Guru Gobind Singh Indraprastha University, Dwarka Sector 16C, Delhi, India

ABSTRACT

A study was conducted on the captive herd of Manipur Brow-antlered Deer (Rucervus eldii edii) at National Zoological Park, Delhi from February 2016 to January 2017 in order to determine changes in their behavioural patterns inside the enclosures. Observations took place for the period of six hours between 10:00 to 16:00 hours each day. Two methodologies i.e., focal-animal and scan sampling methods were utilized. Adult male and sub-adult male spent most of their time in feeding (24.05±2.48 & 21±6.18) in the year 2016-2017 respectively while adult female and sub-adult female consumed more time in resting

(21.97±2.58 & 23.55±2.56). Fawns were found to spend their maximum time in resting (18.22±5.41) inside the enclosure. There were no significant differences between all age-sex variations for all activities pattern. The spread of time activity budget of all age-sex classes of Manipur Brow-antlered deer has also been assessed. The group composition of Manipur Brow-antlered deer were found to spent their more time in behavioural activities like feeding (18.3 %) and resting (18.2%) followed by alertness (12.46%), locomotion (12.19%), ruminating (11.48%) and on other state or event(11.35%) in the National Zoological Park, Delhi.

Introduction

The Manipur Brow-antlered deer having scientific name *Rucervus eldii eldii* (M'Clelland, 1842), and the local name Sangai, is the Indian form of four subspecies of Eld's deer. It comes under the category of "Endangered" under The IUCN Red List of Threatened Species (Gray et al., 2015) and protected under the Schedule I of the Indian Wildlife (Protection) Act, 1972. This rare, endemic and endangered subspecies are protected in its wild habitat at Keibul Lamjao National Park of Manipur State as well as in the thirteen zoos of India.

National Zoological Park, Delhi is one of the large zoos holding the maximum captive population of Manipur Brow-antlered deer under the Conservation Breeding Programme across the country. For a sustainable growth and the development of these deer population in zoos, behavioural studies play a very important and imperative role. Animal behaviour analysis serves one of the major priorities in terms of conservation breeding under captivity (Greggor et al., 2016). This research in captivity has found to be very useful in an ex situ environment regarding animal's reproductive success.

Breeding behaviour of this deer had been described at Kiebul Lamjao National Park, Manipur[4] and preliminary studies were done at Delhi Zoo also (Sankhala and Desai, 1970). General behavioural patterns like resting, feeding, ruminating, locomotion, vigilance, etc. as well as reproductive behaviours of *Rucervus eldii eldii* had been recorded in their *ex situ*

environment (PHVA, 1992). Some studies have been carried out on the ecology and behaviour of *Rucervus eldii thamin* in European zoos (Wall and Hartley, 2017) as well as in semi-captive herd of *Rucervus eldii hainanus* in China (Zeng et al., 2011). Also, rut-induced changes in the activity budgets of male *Rucervus eldii hainanus* were also studied on the Hainan Island of the China (Ding et al., 2012). But very few investigations have been carried out on the detailed activity budget of the Manipur Brow-antlered deer behaviour in natural condition as well as in captivity in India.

For this purpose, a thorough understanding of animal's behaviour is important to successfully farm and breed a species in captivity. The knowledge of entire group and each individual's behaviour of animal serve as one of the major requirements for conservation breeding programme of wild population in captivity. It is necessary for the zoos to recognize the value of behaviour analysis for the delivery of essential animal health and welfare services (Maple and Segura, 2015). The objective of this paper was to measure the activity budget of the Manipur Brow-antlered Deer (*Rucervus eldii edii*) to address their age-sex class variation and to assess the influences of captivity on its behavioural displays in National Zoological Park, Delhi. This behavioural study can lead to develop a more scientific enriched enclosure essentially required in terms of captive environment management.

Materials and Methods

Study area

This study was conducted at the National Zoological Park, which is one of the large zoos (188.62 acres) in India. The study animal Manipur Brow-antlered Deer were kept in two mixed herds in a large enclosure divided by a partial fence having total area of 8006square metres in Beat no. 05 of the Zoo. This enclosure contains many shrubs and trees of *Prosopis juliflora* in its arena. This zoo is having diverse flora and various types of captive species in naturalist environment which attracts a large number of visitors every day.

Methodology

Behavioural observations were carried out in the 12 individuals (3adult males, 2 sub-adult males, 3 adult females, 2 sub-adult females and 2 fawns) which were selected on the basis of simple random sampling among 53 individuals of Manipur Brow- antlered Deer in the period from February 2016 to January 2017 for 156 days in the National Zoological Park, Delhi. Data were collected during the normal operating hours of the zoo, i.e., from 10:00 h to 16:00 h. Observation hours were equally distributed and collections of data were made using focal-animal and scan sampling methods (Altmann, 1974).

Each behavioural sampling session was initiated with focal-animal sampling of predetermined individuals in the group for duration of 20 minutes i.e., total of 18,720 minutes. This was followed by scan sampling of one minute duration in the entire group i.e., total of 936 minutes. The next focal was conducted after the completion of scan sampling. Focal-animal sampling of an individual represents the most complete record of behaviour and is the only way to collect data in sequences. The scan sampling also provides the easiest method for estimating the percentage of time spent in specific activities of the group in various locations of the enclosure (Crockett and HA, 2010). Recording of scan data was done on all subjects for one minute from the left to the right of the enclosure between focal samples for 6 hours on each day of observation. Time spend on each activity was recorded and mean time invested (minutes per hour per day) was calculated.

Based on preliminary observations, the following ethogram was prepared for Manipur Brow –antlered Deer in the National Zoological Park, Delhi:

Table 1 showing ethogram of Manipur Brow-antlered Deer (*Rucervus eldii eldii*)

Behaviour pattern	Type	Category	Abbreviation	Definition
Feeding	Feeding	State	FE	Eating ration provided; actively biting or chewing, licking salt, drinking water
	Suckling	State	SC	Fawns suckle anteriorly, between the front legs of the hind; laterally, from the side and posteriorly, behind the hind through her back legs
Foraging	Foraging	State	FR	Searching food; Head down foraging on pods of *Prosopis juliflora* (in the arena)
Ruminating	Ruminating	State	RU	Standing or resting , regurgitating then chewing cud
Inactive Standing	Inactive standing	State	IS	Not engaged in any activity and just standing
Resting	Resting	State	RE	Lying with eyes open or closed
Locomotion	Locomotion	State	LC	Walking, running, trotting or cantering; Short and long movements; sometimes together, moving in groups
Alertness	Vigilance	State	VI	Animal is still, alert and gazing at stimuli or run
	Barking	State	BK	A series of short barks; an alarm call or a territorial call
	Watching	State	WT	Head up and observing environment, other deer or human visitors.
Others		State or Event	OT	Grooming, Defecating-Urinating, Affinitive Interaction, Agonistic Interaction, Sexual Behaviour, Territory marking, etc.; other behaviours with infrequency such as stereotypic behaviour and homosexual behaviour, etc.; Non-observable i.e., animal

				could not be seen, thus state could not be determined

Activity budget was calculated by given formula (Crockett and HA, 2010):

1. Percentage of time (focal-animal sampling) = (Total duration of behaviour / total duration of observation) x 100
2. Percentage of time (scan sampling) = (Number of point samples when behaviour was scored / total number of point samples) x 100

Kruskal-Wallis test (Santosa et al., 2014) was used to measure the behaviour and sexual differences between each age class of Manipur Brow-antlered deer in the National Zoological Park, Delhi. Data were analysed using SPSS 22 statistical package with a significance level of p = 0.05.

Results

Focal Sampling

The result showed that adult male spent more time in feeding (24.05±2.48) and less in foraging (6.53±0.92) inside the enclosure while the sub-adult male dedicated more in feeding (21±6.18) and less in inactive standing (3.08±0.55). Adult female were found to spend most of the time in resting (21.97±2.58) and very less in foraging (3.62±0.77) and similarly, sub-adult female spent more time in resting (23.55±2.56). The time spent by the fawn in resting was (18.22±5.41) and the foraging behaviour was only (4.98±1.42). It was observed that all age-sex classes of Manipur Brow-antlered deer spent most of their time for feeding and resting which was followed by alertness and ruminating (Table 2).

The maximum time spent in feeding was by adult male (24.05±2.48) than other age-sex classes and least was in fawn (14.96± 2.8). Alertness was higher in sub-adult female (18.71±0.42) followed by sub-adult male, fawn and adult female and adult male (8.6±3.6). Regarding rumination, adult male and adult female spend almost equal time (17.2±4.02) and (17.11±0.57). Least rumination was recorded in fawn (7.52±1.73). Activity budget of other behaviours were also recorded *viz.* foraging, inactive standing, locomotion and others. There were no significant differences between all age-sex variations for all activities pattern (Kruskal-Wallis test, p> 0.05).

Table 2 showing activity budget of Manipur Brow- antlered Deer (different age-sex classes) in the National Zoological Park, Delhi

Activity Patterns	Percentage of time spent					Different time budget between all age-sex class compared by Kruskal-Wallis test
	Adult male (Mean ± SE)	Sub adult male (Mean ± SE)	Adult female (Mean ± SE)	Sub adult female (Mean ± SE)	Fawn (Mean ± SE)	
Feeding	24.05±2.48	21±6.18	16.17±0.79	18.66±0.22	14.96± 2.8	χ2=4.416; df=4; p=0.353
Foraging	6.53±0.92	10.07±2.05	3.62±0.77	4.48±1.45	4.98±1.42	χ2=7.491; df=4; p=0.112
Ruminating	17.2±4.02	12.38±3.75	17.11±0.57	16.11±0.33	7.52±1.73	χ2=4.936; df=4; p=0.294
Inactive Standing	8.01±1.9	3.08±0.55	4.73±0.79	5.44±2.41	6±1.19	χ2=5.474; df=4; p=0.242
Resting	18.9±1.77	11.12±0.89	21.97±2.58	23.55±2.56	18.22±5.41	χ2=6.064; df=4; p=0.242
Locomotion	12.5±3.01	8.98±4.08	12.14±1.82	8.62±1.79	16.24±2.82	χ2=4.756; df=4; p=0.313
Alertness	8.6±3.6	16.43±4.09	15.65±1.8	18.71±0.42	16.27±5.44	χ2=3.295; df=4; p=0.510
Others	13.2±2.41	11.77±5.05	8.52±1.76	4.36±1.18	6.66±0.97	χ2=5.936; df=4; P=0.204

The spread of time activity budget of all age-sex classes of Manipur Brow-antlered deer from 10.00 to 16.00 hours has been presented in Figures 1-6.
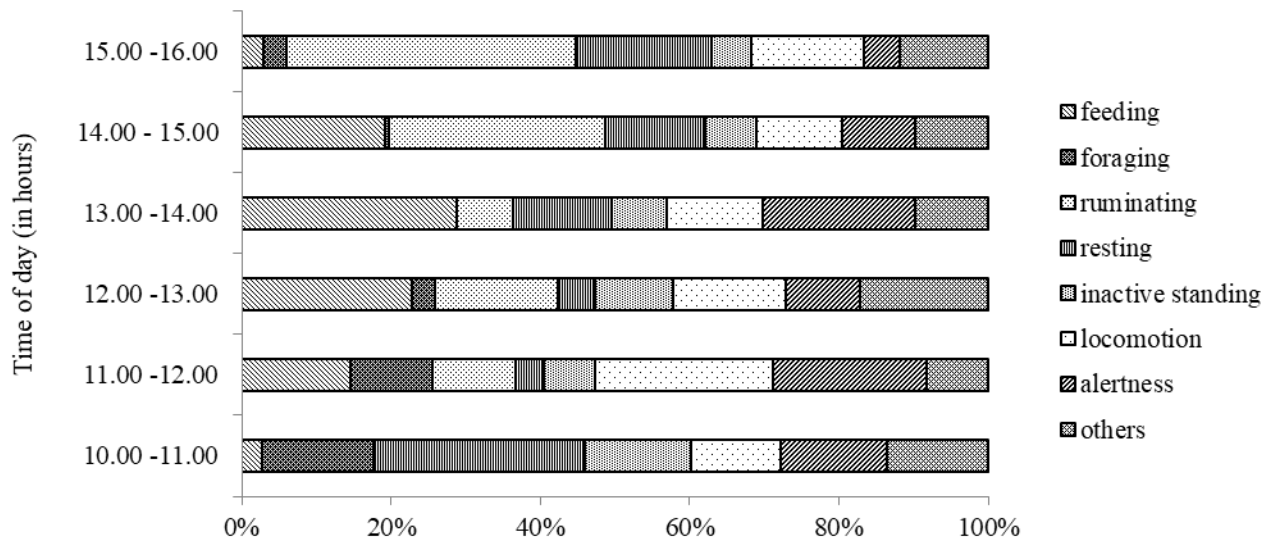

Figure 1 represents time budget of adult male in National Zoological Park, Delhi

In case of adult male, the peak hours of feeding were 13.00-14.00 hours. They spent most of their time for resting, foraging and inactive standing at 10.00-11.00 hours. The peak hours of ruminating were 15.00-16.00 hours. Behaviours like locomotion and alertness were recorded maximum at 11.00-12.00 hours. 12.00-13.00 hours were the peak hours for other activities.
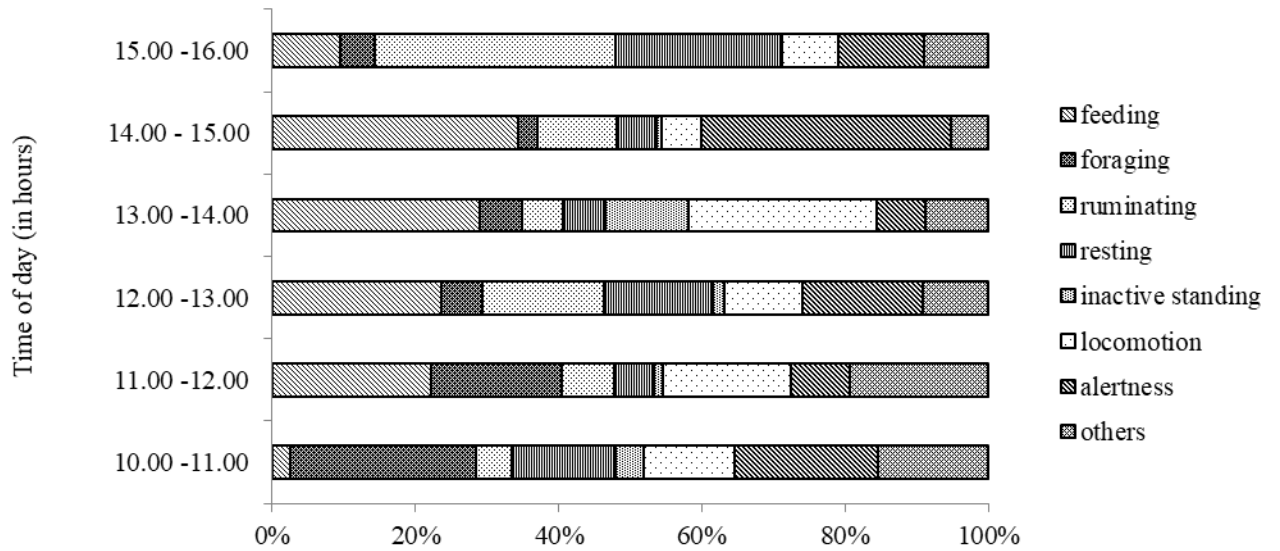
Figure 2 represents time budget of sub-adult male in National Zoological Park, Delhi

Sub-adult male dedicated more time in feeding and found to be in maximum alertness at 14.00-15.00hours. The peak hours for foraging were 10.00-11.00hours. They spent more time in ruminating and resting at 15.00-16.00hours. The peak hours of locomotion and inactive standing were 13.00-14.00hours. Maximum engagement in other activities was recorded at 11.00-12.00 hours.
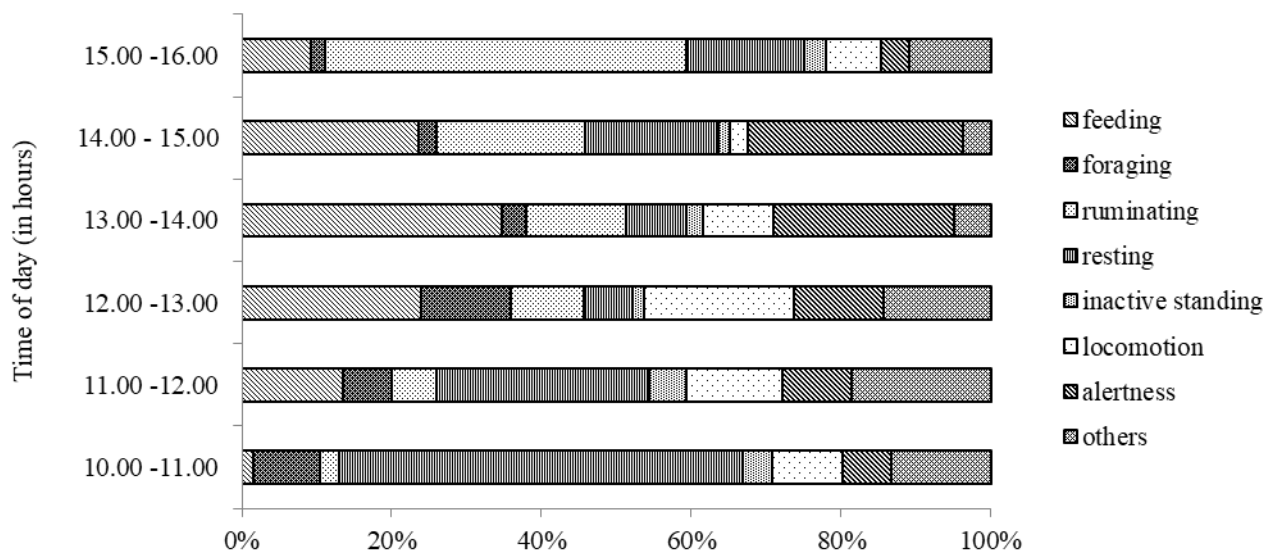

Figure 3 represents time budget of adult female in National Zoological Park, Delhi

Adult female spent more time in feeding inside enclosure at 13.00-14.00 hours. The peak hours of foraging and locomotion were 12.00-13.00 hours. Ruminating maximum occurred at 15.00-16.00 hours. They spend most of their time for resting at 10.00-11.00 hours. Inactive standing and others were mostly observed at 11.00-12.00 hours. They showed maximum alertness at 14.00-15.00 hours.
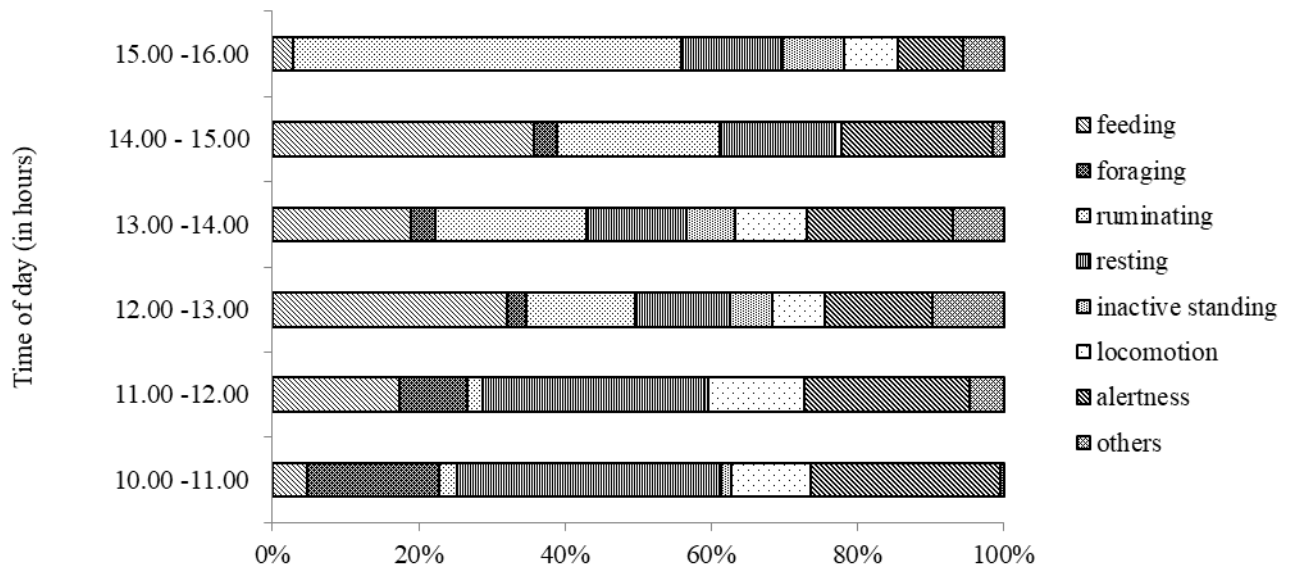

Figure 4 represents time budget of sub-adult female in National Zoological Park, Delhi

In case of sub-adult female, feeding was mostly observed at 14.00-15.00 hours. They spent their most time in foraging and in resting at 10.00-11.00 hours inside enclosure. The peak hours of ruminating and inactive standing were 15.00-16.00 hours. Locomotion and alertness were mostly recorded at 11.00-12.00 hours. They were found to be engaged in other activities mainly at 12.00-13.00 hours.
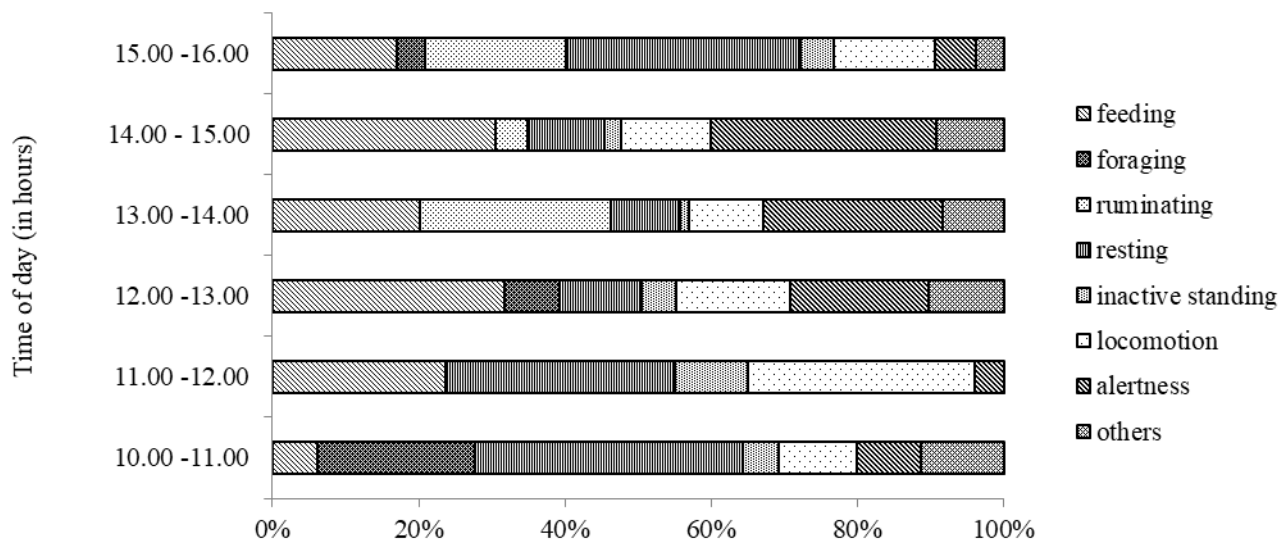
Figure 5 represents time budget of fawn in National Zoological Park, Delhi

Fawn spent most of their time for feeding at 12.00-13.00 hours. The peak hours of foraging, resting and others were 10.00-11.00 hours. They mostly ruminate at 13.00-14.00 hours. The peak hours of inactive standing and locomotion were 11.00-12.00. The maximum alertness in fawns was observed at 14.00-15.00 hours.

Scan Sampling

The group of Manipur Brow-antlered deer in the National Zoological Park, Delhi spent their more time in feeding (18.3 %) and resting (18.2%). They were found to be spending their least time in inactive standing (7.17%) and foraging (8.82%). They spent approximate equal time in ruminating, locomotion, alertness and others.

Table 3 Activity budget of Manipur Brow- antlered Deer (herd) in the National Zoological Park, Delhi

Activity Patterns	Percentage of time spent (%)
feeding	18.3
foraging	8.82
ruminating	11.48

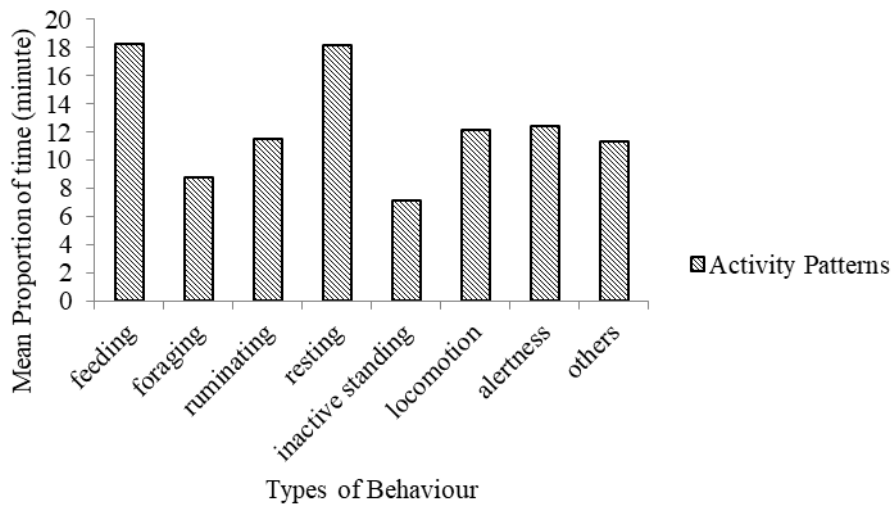|	
resting	18.2
inactive standing	7.17
locomotion	12.19
alertness	12.46
others	11.35

Figure 6 Activity Budget of group composition of Manipur Brow-antlered deer in the National Zoological Park, Delhi

Discussion

Behavioural studies have been carried out in individuals of different age-sex classes as well as in the whole herd/group of Manipur Brow-antlered deer in the National Zoological Park, Delhi.

Male were found to be more active in feeding. This indicates male dominancy on food over female and fawn in captivity (PHVA, 1992). The time spent for feeding and resting collectively formed a larger share of daily activity. Feeding include ration like green fodder, tree fodder and the mesh during the different times of the day provided inside the kraal area.

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Page | 71

These variations in feed would lead to enrich the feeding habits and preferences inside the captivity (PHVA, 1992). Foraging behaviour was mostly recorded in sub-adult male than other age-sex classes. They actively foraged on *Prosopis juliflora* pods inside the enclosure. Feeding was generally followed by collectively resting and ruminating behaviour. Rumination was observed slightly higher percentage in males than in females. They chewed the given feed for several minutes. If the animal is disturbed while rumination, the pattern also gets disturbed and sudden changes may be seen. Generally, deer feed for a while and rest for some time and reinitiate feeding (Khanpara, 2009). It was least observed in fawns because they started to take solid food after 3-4 months of suckling mother's milk i.e., after weaning. Female spend most of their time in resting than male and fawn. This may be because of their less engagement in other activities inside the enclosure. Resting is closely associated and inter-bridging activity with feeding, rumination, locomotion and inactive standing. It was observed in present studies that the animals generally selected specific site for resting. They rest in the arena which is full of stones, brick pieces, thorny shrubs and trees of *Prosopis juliflora.* Short walking movements were also observed.

Inactive standing was mostly observed and alertness was least recorded in adult male; as it responds less to disturbances created by the variables present inside and outside the enclosure than the other individuals. Vigilant behaviour or alertness was mostly observed in female, especially in mother deer than fawns and male. Fawns show a higher percentage of interactive behaviour towards their mothers and besides their mothers showed a higher percentage of vigilance or alertness. Adult mother with fawn shows more vigilant behaviour than adult female without fawn (Santosa et al., 2014). Vigilant behaviour mainly occurred due to the presence of visitors in the display area and movement of zookeepers inside the enclosure. They stand alert and stare the visitors and zookeepers. But in the presence of fewer visitors, deer roam freely inside the arena without any sign of alertness or vigilance. In captivity, the high density of visitors during specific seasons at specified time of the day is possibly one of the major threat or disturbing activity in *ex situ* habitat to which captive animals respond very soon (Khanpara, 2009). Locomotion was recorded approximately of equal duration in all age-sex classes.

Other behavioural activities like grooming, defecating-urinating, affinitive interaction, agonistic interaction, etc. were observed all year round. Males were found to spend more time in these activities than females and fawn.

Sexual behaviour in both male and female were recorded during breeding season. During this season, activities such as rubbing forehead or antlers, flehmening, fighting, territory marking, etc. were recorded more in males than females. Rubbing forehead or antlers on vegetation, urination and defecation in specific places can be considered as scent marking activity. The functions of scent marking include inter-sexual communication (Zala et al., 2004) as well as territorial marking activity (Roberts, 2012). Female were seemed to be more vigilant during the breeding season and were chased by adult as well as sub-adult male.

Collectively, feeding, resting, alertness and ruminating have been recorded most time during the day which is then followed by locomotion, foraging, inactive standing and other activities. The behaviour of this species was influenced by age, sex, social group, housing and food availability in an *ex situ* environment.

Conclusion

Observation of activity pattern and time budget analysis of all age-sex classes of Manipur Brow-antlered deer has been done by utilizing focal-animal and scan sampling methods from February 2016 to January 2017 in the National Zoological Park. An ethogram was prepared which serves as a catalogue for all the different kinds of behaviour observed in these species. Daily activity budget and peak hours explained about changes in the behavioural pattern and their occurrences in the study period.

The study revealed that these deer spent most of their time in feeding in the kraal area and resting in the arena inside the enclosure. In order to avoid the boredom and inclination towards particular behavioural pattern, the enrichment of enclosure should be done in a more naturalist manner, imitating their natural habitat. This would results in the active engagement towards the other behavioural activities also. Bed of green grass should be developed in the arena which can provide convenient place for resting and locomotion. There should be multiple feeding stations in the arena for the avoidance of monopolization of food by the dominant individuals. This would lead to the enhancement of feeding pattern and food

preferences of the other age groups. Also, unendurable activities of visitors should be prevented to avoid vigilance or stressful behaviour in captive Manipur Brow-antlered deer species.

This behavioural study provides significant knowledge and thorough understanding about different behavioural activities of Manipur Brow-antlered deer under an *ex situ* environment. It also led to the identification of captive environmental challenges and behavioural related problems. Thus, it will serve as one of the major tools in terms of conservation and management of Manipur Brow-antlered deer in National Zoological Park, Delhi, India.

Acknowledgement

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Page | 74

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Page | 75

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