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Activity Pattern and Time Budget Analysis of Nilgai (*Boselaphus tragocamelus*) in Captivity at Alipore Zoological Garden, Kolkata, India

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Abstract: Wild herbivores are difficult to house in captivity due to their wide home range and specific diet. Data of their behavioural pattern and time budgeting are crucial for their welfare and captive management. Hence, a comparative study on overall seasonal behavioural patterns and hourly activity budget of male, female and calf nilgai (*Boselaphus tragocamelus*) were conducted from August, 2022 to June, 2023 in the captivity at Alipore Zoological Garden, Kolkata, India. The activities were recorded using focal sampling and scan sampling method from 10.00 to 17.00 h. The nilgai exhibited significant variations in activities among the seasons, among the sex classes, and among the different hours of day. For all the studied seasons and for both the male and female and their calf, foraging activity was dominant with significantly ($P<0.05$; DMRT) maximum time spent, followed by resting, locomotion, and inactive standing. Among seasons, significantly higher ($P<0.05$; DMRT) foraging and resting were noted during summer and lower during winter, while locomotion was significantly maximum in winter and lower in summer for all the studied nilgai. A little time share was allocated for the other activities by the nilgai and the time budget did not vary significantly (DMRT) among the season or sex classes. Nilgai spent maximum time in foraging from 10:00 h to 12:00 h and 15:00 h to 17:00 h, when the environmental temperature was low. Similarly, resting was also linked with environmental temperature, was found high during the hot hours of daylight. The findings of the present observational study on activity pattern and time budget analysis of captive nilgai will provide a baseline information which would be helpful in improving the management strategies for their welfare.

Keywords: Activity pattern, Alipore Zoological Garden, Focal sampling,nilgai, Scan sampling, Time budget

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Introduction

The Blue bull (*Boselaphus tragocamelus*), commonly known in India as nilgai, an ungulate, which belongs to the family Bovidae of order Artiodactyla (Grubb, 1993), is the only species of Boselaphus (Fall, 1972). They show close relation with four-horned antelope (*Tetracerus*

quadricornis), African eland (*Taurotragus oryx*) and cattle (*Boss spp*.). Nilgai looks like a horse (Kusum, 2018) and is the largest Asian antelope, endemic to the Indian subcontinent (Leslie, 2008; IUCN, 2016) and widely distributed in arid and semi-arid parts of north and northwest India (Prater, 1971) from the Himalayan foot hills to central India, Mysore, and also in the lowlands of Nepal (Pandey *et al*., 2022). It is not noticed in Eastern Bengal, Assam and Malabar Coast. It is reported that no nilgai population is present in Pakistan, but found at the India-Pakisthan border areas in Kasur and in Bhawalpore (Kusum, 2018). They were stocked in Royal Karnali-Bardia wildlife preserve of Nepal and also were introduced in the United States and Mexico (Dinerstein, 1979; Corbet and Hill, 1992). Nilgai stands 1.30 m to 1.55 m at shoulder and measures 1.7 m to 2.1 m in head-body length with a tail of 45 to 50 cm long. On the neck, there is a mane and, on the throat, a tuft of long hair. It has strong, narrow legs and a big-sized body that slope down from the shoulder. Nilgai are sexually dimorphic. The adult males are dark iron-grey, sometimes colour is varied from bluish to brownish grey, while the females, young males and calves are pale brown in colour (Schaller, 2009). Males possesses small, smooth and about 20 cm long cone-shaped horns while females are without horns (Goyal and Rajpurohit, 2000). Males are larger than females, with the weight of an adult male from 109 kg to 288 kg and female, from 100 kg to 213 kg (Nowak and Walker, 1999).

Nilgai is a shy kind of animal with strong eyesight and hearing capability (Schaller, 2009). They are social animals, generally observed in all-bull herds or in bisexual herds. A bisexual herd is a mixed sex herd of varying size, mostly found with 4 to 20 individuals of both sexes and of all age classes (Goyal and Rajpurohit, 2000). All bull herd or single sex herd may comprise of 2 to 8 adult and sub-adult males (Goyal and Rajpurohit, 2000). For the most part of their distribution, bisexual herd were clumped with an average herd size of 5 to 6 individuals per herd and with a single adult bull who leads the pack, but sometimes 2 or more bulls are noticed in one androgynous pack.

In India, nilgai prefers a variety of habitats (Mathai, 1999), can be found in open places with flat or undulating topography (Berwick, 1974). They avoid dense steep forests and favour grassland and scrublands with few trees and patches of scrub (Chakraborty, 1991; Sankar, 1994; Khan, 1996; Schalle,r 2009). They are mixed feeders, both grazer and browser, bulk of their diet are grasses (Sankar and Vijayan, 1992; Solounias and Moelleken, 1993). When there is a lack of fodder as a result of a drought, nilgai continues browsing; when there is no drought, they shift towards an intermediate-grass diet. Nilgai live in close proximity to human settlement and have a negative impact on the local livelihoods of farmers as they destroy huge quantity of crops and vegetables both by trampling and eating the crops and seriously damage agriculture fields that are close to forest areas (Rahmani, 2001). Hence, they have been considered as anagricultural pest and often they are encountered in the agricultural field. Sometimes they cause fatal injuries to the farmers by their sharp horns (Gorchiya *et al*., 2022). In this way human-nilgai conflict arises (Aryal, 2007). Moreover, one of the major causes of human-nilgai conflict is that their natural habitat is being lost due to habitat destruction, over-exploitation, conversion to agricultural field, urbanization, pollution, poaching and the human and livestock pressure (Tiwari and Ghimire, 2021).

Though nilgai are listed as "least concern" according to Red Data Book of the IUCN, there is a need of proper management of this crop pest and also need a conservation strategy for this conflict-causing wild blue bull (Beger-Tal *et al*., 2011). For these, a good amount of knowledge regarding the behaviour of nilgai, is essential. Behavioural study includes all the responses displayed by the studied animal to their social, biological and the physical environments and all the reactions they perceived and how they make their survival strategy through the action of natural selection and sexual selection

(Cacioppo *et al*., 2000; Sachser *et al*., 2013). Behaviours are variables among the sexes, age classes and also among the herds. The environment, weather, and the accessibility of food affect how much time the nilgai spends engaging in different activities. For an animal to maintain a healthy energy balance and ensure its survival, how and where it spent its time engaging in different activities is crucial. When there is less food available, feeding occurs for a greater time. Feeding takes less time if food is plentiful and easily accessible. Nilgai divide their time between basic needs for food, locomotion, and social engagement like reproduction and rest, taking advantage of the habitat that is available to them. Some prior studies were conducted on the ecology and behaviour of nilgai in the wild (Lacey, 1969; Acharjyo and Misra, 1973; Mirza and Khan, 1975; Chitampalli, 1983; Sheffield *et al*., 1983; Oguya and Eltringham, 1991; Sankarand Vijayan, 1992; Bohra *et al*., 1992). Very few studies were carried out on the detailed activity budget of the nilgai behaviour in captivity in India (Goyal and Rajpurohit 2001). Basic information about the behaviours of nilgai and identification of their behaviour and prediction of activities are most essential for a better formulation of their management strategy, where crop destruction by them could be reduced, and thereby ensuring their healthy population. Moreover, a detailed knowledge of studied animal's behaviour in terms of entire group behaviour and also each individual's behaviour is most crucial for successful farming and conservation breeding programme of wild population in captivity. This information is valuable for the zoos for offering welfare services and good health to the captive species (Maple and Segura, 2015).

Owing to insufficient information about captive nilgai ecology, the primary focus of this observation was to establish behavioural profiles of male, female and calf of nilgai (*Boselephus tragocamelus*) in captivity. The present study aimed to measure the diurnal activity pattern, activity budget in various hours of a day and also to determine the seasonal impact on its activity in captive condition at Alipore Zoological Garden, Kolkata, India.

Materials and Methods

Study site

The study was conducted in captivity at Alipore Zoological Garden (22.5372144°N 88.3320919°E), Kolkata, which is one of India's largest zoos (covering 64 acres). In the Zoological Garden, a wide range of animals from all the vertebrate groups are present. Average temperature of Alipore Zoological Garden during study period in winter season was found to range between 10 °C to 20°C, whereas in summer it was between 32°C to 43°C. Typically, the temperature reaches its highest point during the noon hours, specifically between 12:00 h and 15:00 h. Presence of diverse flora and rare and endangered species of captive animals in a naturalist environment draws a huge number of tourists every day in this zoo.

Studied animal

Nilgai, the studied animal, was housed in an enclosure (2600 sq m) in the southern section of the zoo. There were three males, four females and two calves. The zoo garden authority distributed the food twice a day at 08:00 h and 16:00 h, primarily consisting of various sorts of grasses, paddy straw, concentrated feed, sweet potato and carrot.

Enclosure of the animal

One side of the enclosure was bordered by a concrete wall and other three sides were guarded by netted fence. Among the three netted fence sides, two sides were adjoined with two empty enclosures and one side was free for the visitors (Fig. 1). Enclosure ground was sparsely covered with grasses. The enclosure also had a big sized Termarin tree which was totally uprooted due to storms. Inside the enclosure, under a shed, there were two concrete troughs, one dedicated for food and the other for drinking water. There was also a fenced room present inside the enclosure. Branches from the line of trees, present outside the enclosure, was found to extend over the area

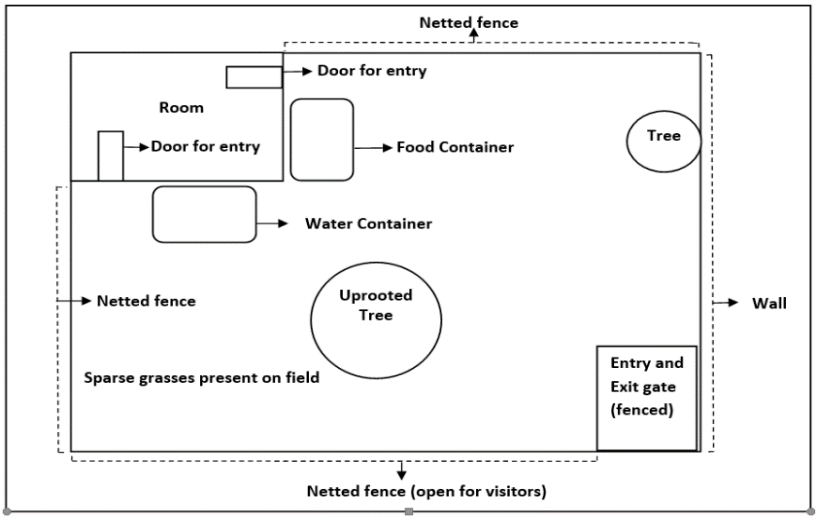

Fig. 1: Layout of the nilgai enclosure at Zoological Garden Alipore, India (based on visual observation during the study).

of the enclosure.

Data collection

Activity pattern, behaviour and social organisation of nilgai kept in captivity at the Zoological Garden in Alipore, Kolkata was observed and recorded from August, 2022 to June, 2023, having 11 months of study period including 3 months from monsoon, 4 months from winter and 4 months from summer. Direct observation with unaided eye was continued for 7 hours from 10:00 h to 17:00 h, twice in a week. All the activities by the studied animals, were collected using both focal sampling and scan sampling techniques (Altmann, 1974). For the recording of data, the behavioural sampling sessions began with focal sampling of the selected individual within the group for the duration of 4 min. Subsequently, a one-minute scan sampling of the entire group was conducted. After the completion of the scan sampling, the next focal sampling session was started. For the capture of one minute scan sampling data for all the subjects in the enclosure, data were collected from left to right side of the enclosure between focal samplings for 7 h of each day. The amount of time spent on each activity was noted. The male, female and calf were separately sampled throughout the day using the focal animal sampling method. Data of the scan provides the insight of the social organization of the nilgai, whereas the focal sampling provides the most comprehensive record of the individual behaviour.

Ethogram

Naturally occurring continuous flow of activities performed by an animal, was fragmented into a list of behaviours. This list is the complete catalogue of the behavioural pattern of that animal and is termed as ethogram. Time spent for each activity displayed by the animal was measured in terms of time budget. Based on earlier behavioural studies on nilgai (Gautam and Bissa, 2015; Pandey *et al*., 2022) and preliminary observations, an ethogram was made for this study on nilgai (Table 1). A total of 13 activities were identified for the nilgai in Alipore Zoological Garden.

Data Analysis

Activities were estimated by counting the number of events (frequency). Activity time budget in percentage was calculated by using the following formula (Crockett and Ha, 2010):

1. Focal-animal sampling (time spent in a particular activity %) = (total time spent in a particular activity during the sampling period/total duration of observation) × 100

Table 1: Ethogram used for collecting behavioural data of nilgai, *B. tragocamelus* in captivity at Alipore Zoo, Kolkata (Gautam and Bissa, 2015; Pandey *et al*., 2022)

Behaviours	**Description**
Feeding of offered feed	Eating food provided by the zoo authority
Drinking	Consuming water.
Suckling	Fawn suckling against its mother's udder, mostly laterally from the side.
Foraging	Searching for food, grazing with its head down and browsing.
Inactive standing	Standing still and not involved in any activities.
Resting	Sitting down with open or closed eyes.
Locomotion	Walking or running and changing its location.
Alertness	Vigilant and watching standing still, gazing at some object or visitors.
Affinitive interaction	Grooming each other, physical contact involved with no conflict.
Ano-genital sniffing	Sniffing anogenital regions through nostrils.
Environmental sniffing	Sniffing and licking objects or vegetation.
Self-directed behaviour	Grooming of self, licking itself and activities directed to itself.
Elimination	Release of urine or faeces from the body.

2. Scan sampling (time spent in a particular activity %) = (number of point samples when a particular behaviour was noted/total number of point samples) × 100

The experimental data were presented as mean percentage ± standard error (SE). One way analysis of variance (ANOVA), followed by Duncan's multiple range tests (DMRT) was done for multiple comparisons at the significance level of 0.05 to compare the differences in activity patterns for hourly and seasonal data. All the graphical representations were prepared by using MS-Excel software.

Results

Focal sampling

The behavioural pattern of male, female and calf of nilgai were investigated, focusing on the various activities exhibited by them. A total of 10,080 min of diurnal behavioural data by focal sampling of male, female and calf separately were obtained from each of the three seasons. Similarly, 2520 min data were recorded by scan sampling method for each season. Analysed data were presented as mean percentage of time spent by the nilgai.

Feeding activity was found dominant in both the male (Fig. 2) and female (Fig. 3), and also in calf (Fig. 4) with 31.65%, 35.40% and 32.06%, respectively during the monsoon season, 28.70%, 32.77% and 31.43%, respectively during the winter season and with 36.48%, 42.89% and 38.84%, respectively during the summer season. Feeding was done almost exclusively by foraging activity and during all the three studied season, the male, female and calf dedicated a significant amount of time in foraging activity.

During the monsoon season, the male and female nilgai were found to spend maximum time in resting (30.16% and 31.27%, respectively) followed by foraging (28.32% and 30.79%, respectively), locomotion (11.54% and 12.75%, respectively) and then in inactive standing (11.57%), whereas the calf spent significantly maximum time in foraging, followed by resting, locomotion, inactive standing.

During the winter season, foraging was found to be the dominant behaviour displayed by male, female nilgai and the calf with 24.62%, 27.81% and 27.74%, respectively, followed by resting (24.44%, 23.05% and 19.05%, respectively), locomotion (16.46%, 18.48% and 16.90%,

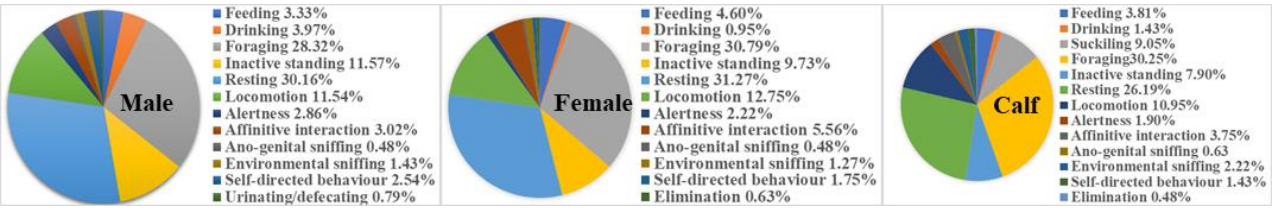

Fig. 2: Percentage of time spent in different behavioural categories by male, female and calf of nilgai during monsoon season at Alipore Zoo, Kolkata.

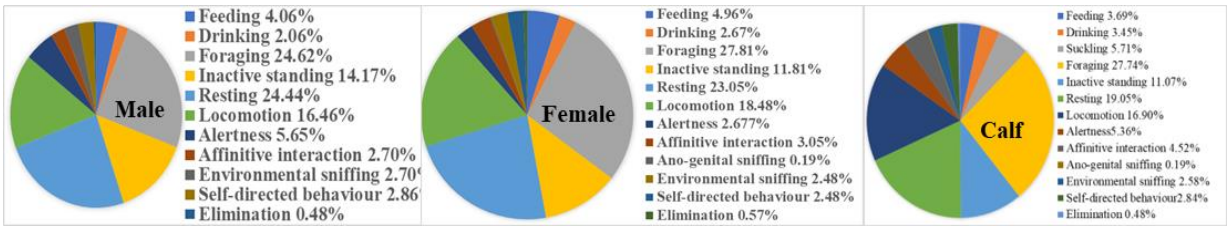

Fig. 3: Percentage of time spent in different behavioural categories by male, female and calf of nilgai during winter season at Alipore Zoo, Kolkata.

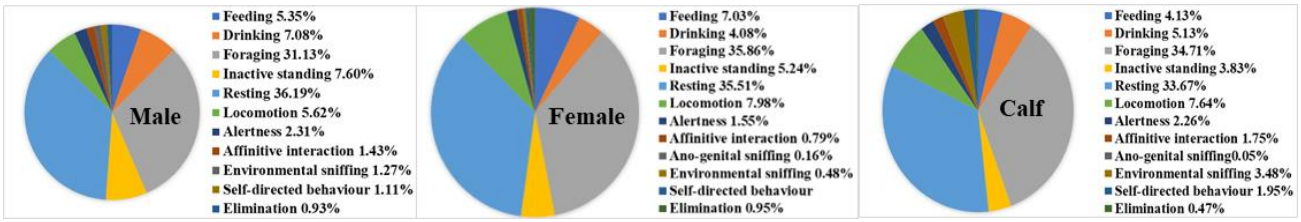

Fig. 4: Percentage of time spent in different behavioural categories by male, female and calf of nilgai during summer season at Alipore Zoo, Kolkata.

respectively), and inactive standing (14.17%, 11.81% and 11.07%, respectively).

When allotted percentage of time for different activities were compared among the male, female and calf, during monsoon season (Fig. 5) it was found that feeding (4.60±0.46), locomotion (12.75±0.26) and affinitive interaction (5.56±0.57) were significantly higher in female, while in male and calf data insignificantly varied. The mean value of time spent for the foraging and resting was higher in female and significantly lower in male for the foraging and in calf for the resting. Drinking (3.97±1.24) and inactive standing (11.57±0.66%) was significantly higher in male, while the calf dedicated significantly less time in inactive standing (7.90±0.35). Time spent for the other activities such as alertness-vigilance, ano-genital sniffing, environmental sniffing and self-directed behaviour did not vary significantly among the male, female and calf.

When data were compared among the male, female and calf, during winter season (Fig. 5), it was recorded a similar trend of results for the feeding, foraging, resting and locomotion activities as observed in monsoon season for the forementioned activities. Inactive standing was noticed significantly higher in male, while the alertness-vigilance was significantly lower in female. Time given for the other behaviours such as drinking, affinitive interaction, ano-genital

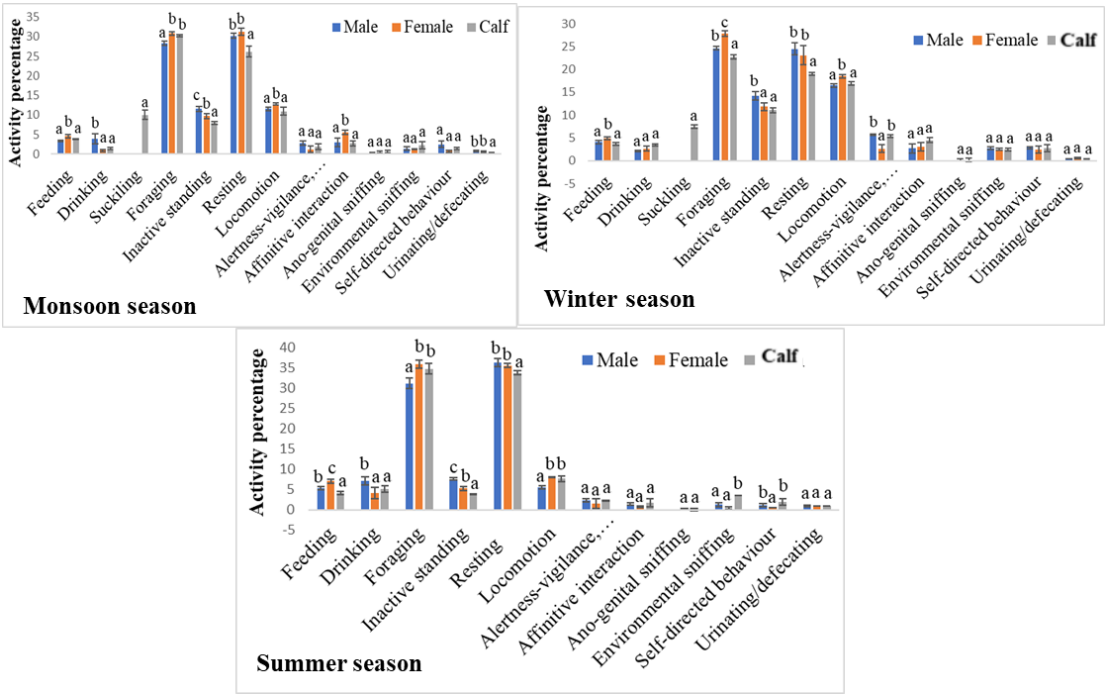

Fig. 5: Comparison of activity budget among male, female and calf of nilgai, *B. tragocamelus* during monsoon, winter and summer season at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

sniffing, environmental sniffing, self-directed behaviour and urinating/defecating did not vary significantly among the male, female and calf.

During the summer season, when data were compared among the male, female and calf (Fig. 5) it was found that the results of resting and the foraging activity were in the same line as found in the other two seasons and the results of inactive standing and drinking activities as in monsoon season. The mean value of feeding and locomotion was higher in female, which was also noted in monsoon and summer season. The values of alertness-vigilance, affinitive interaction, ano-genital sniffing and urinating/defecating did not vary significantly among the male, female and calf.

When data were compared among the three studied seasons (Fig. 6), in case of male it was found that significantly higher value for the feeding, drinking, resting and foraging activities were during the summer season, while lower for the inactive standing and locomotion activities. Female and calf also followed the same trend of results as noticed in male. Among the three studied seasons, significantly higher percentage of time spent for inactive standing, locomotion and alertness-vigilance behaviours and least time spent for resting and foraging activities were noted during the winter season in case of all the studied animal i.e. male, female and calf. During the monsoon season, significantly lowest value for the feeding in male, feeding and drinking in female, and drinking in calf was noted.

When data of hourly activity pattern of male nilgai was compared among the different hours of day, it was found that the peak hours for foraging (37.78%) was 11:00-12:00 h and 14:00-15:00 h in monsoon, whereas 14:00-15:00 h in winter (33.33%) and 15:00-16:00 h in summer (47.78%). Feeding of offered feed was found more at 10:00-11:00 h during the monsoon and winter (13.33% and 26.67%, respectively) and at 11:00-12:00 h during the summer (20%). Drinking was noted maximum at 14:00-15:00 h in monsoon (7.78%), at 11:00-12:00 h in winter (6.67%) and at 10:00-11:00 h in summer (8.89%). Inactive standing

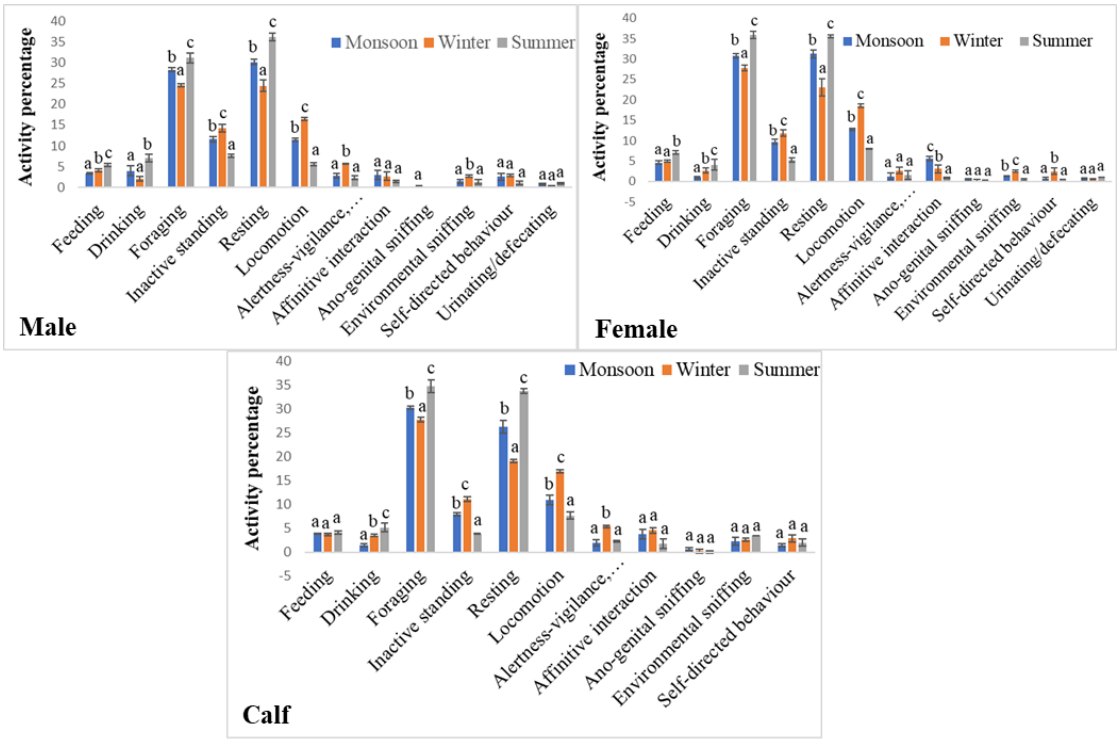

Fig. 6: Comparison of activity budget among seasons in male, female and calf of nilgai, *B. tragocamelus* at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

reached the maximum (18.89%) value at 12.00-13.00 h in monsoon, at 11:00-12:00 h and 16:00-17:00 h (20%) in winter and at 12:00-13:00 h and 15:00-16:00 h (6.67%) in summer. Locomotion was observed peak at 14:00-15:00 h during both the monsoon and summer (22.22% and 12.22%, respectively). The male took maximum rest at 15:00-16:00 h in monsoon and winter (50% and 60%, respectively) and 12:00-13:00 h in summer (71.11%). Alertness was more at 15:00-17:00 in monsoon (4.44%) and at 10:00-11:00 h in winter and summer (6.67% and 3.33%, respectively).

When data of hourly activity pattern of female nilgai was compared among the different hours of day, it was noted that the female nilgai foraged maximum at 14:00-15:00 h in monsoon and summer (52.22% and 50%, respectively), and at 10:00-11:00 h in winter (33.89%). In case of all the studied seasons, feeding of the offered feed reached peak at 10:00-11:00 h (15.56%, 18.89% and 21.11% in monsoon, winter and summer respectively), while drinking activity at 11:00-12:00 h (4.44%, 5.56% and 11.11% in monsoon, winter and summer, respectively). The peak hour for resting was at 16:00-17:00 h during the monsoon (78.89%) and at 12:00-13:00 h during winter and summer (41.11% and 80%, respectively). The female nilgai displayed the maximum locomotion at 11:00-12:00 h during monsoon (25.56%), whereas at 16:00-17:00 h during winter (28.89%) and at 10:00-11:00 h during summer (11.11%).

When data of hourly activity pattern of calf was compared among the different hours of day, it was observed that the calf devoted her most time for foraging activity at 10.00-11.00 h and at 14:00-16:00 h during the monsoon season (40%), at 11:00-12:00 h and at 16:00-17:00 h (30%) during winter season, and at 14:00-15:00 h during the summer season (61.11%). The peak hour of the feeding of offered feed was 11.00-12.00 h in the monsoon and winter (18.89% and 22.5%, respectively) and 10:00-11:00 h in the summer (12.22%). Drinking was mostly observed at 11.00-

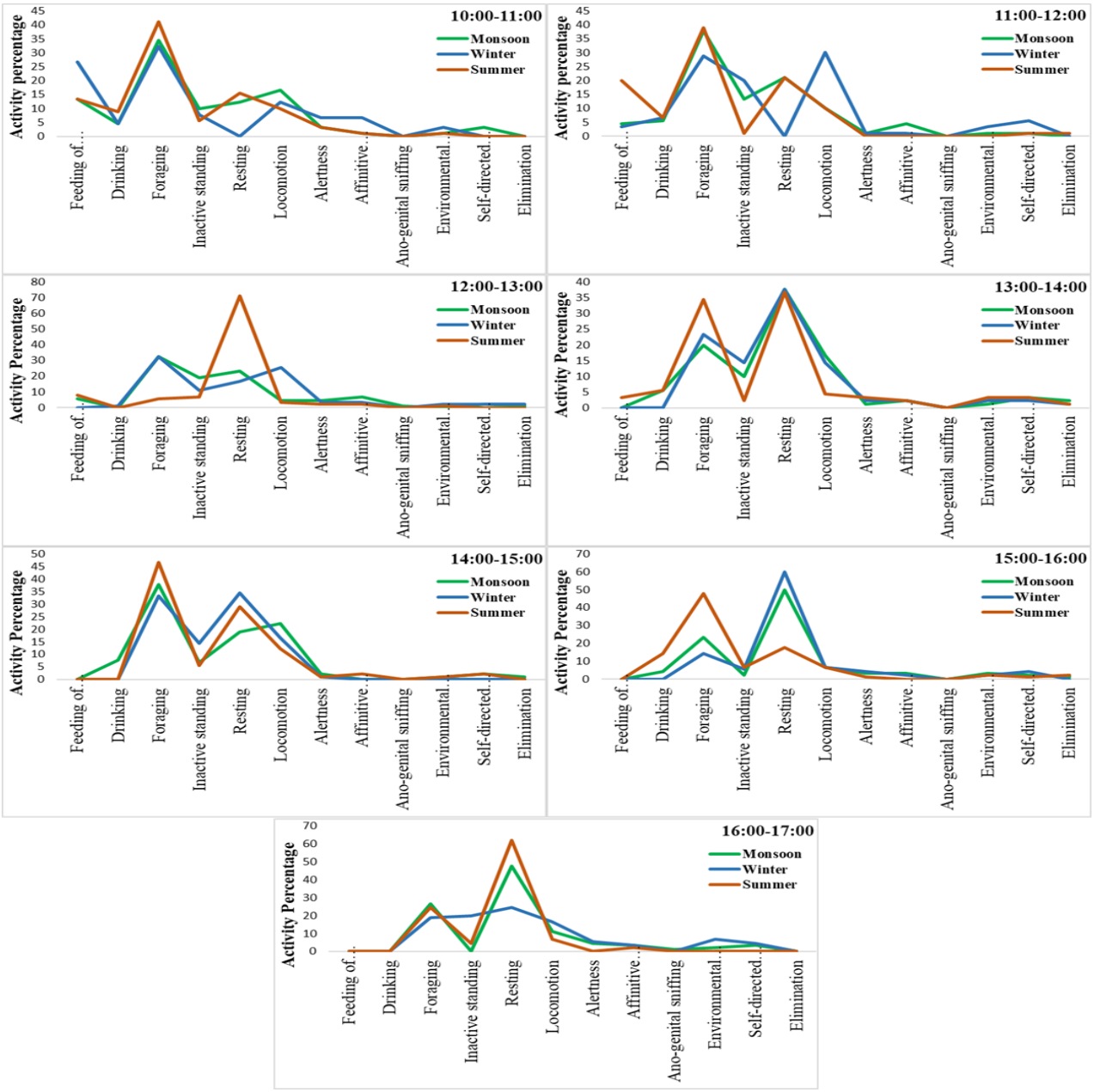

Fig. 7: Comparison of hourly activity budget among seasons in male nilgai at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

13.00 h during the monsoon (4.44%), whereas at 10.00-11.00 h during the winter and summer (12.5% and 14.44%, respectively). During all the three seasons, maximum time spent for inactive standing was noted at 10.00-11.00 h (22.22%, 15.83% and 11.11% in monsoon, winter and summer, respectively). Peak hours for resting were 14:00-15:00 h during monsoon (40%), 15:00-16:00 h during winter (40%) and 12:00-13:00 h during summer (63.33%). The fawn spent more time in locomotion from 11:00 h to 12:00 h during monsoon (16.67%), from 16:00 to 17:00 h during winter (32.5%) and from 11:00 h to 12:00 h during summer (14.44%).

Comparison of the mean percentage of hourly activity pattern of male nilgai among the three studied season from 10.00 h to 5.00 h are presented in Figure 7. When 10.00 h to 11.00 h

was considered, it was observed that time spent for foraging, drinking and resting were higher during summer, whereas for inactive standing and locomotion were found maximum during monsoon and for the feeding of offered feed mixture was more in winter. From 11.00 h to 12.00 h, time spent for foraging and feeding of offered feed were found more in summer, for inactive standing and locomotion in winter. From 12:00 h to 13:00 h, time spent for the behaviours such as foraging, drinking and locomotion were maximum during winter, whereas for inactive standing during monsoon and resting during summer. From 13:00 h to 14:00 h, feeding of offered feed and foraging were found at peak during summer, while inactive standing during winter and locomotion during monsoon. From 14:00 h to 15:00 h, time spent for the behaviours such as drinking, locomotion and alertness were maximum during monsoon and inactive standing and resting during winter, whereas foraging during the summer. From 15:00 h to 16:00 h, time spent for foraging, drinking and inactive standing were more in summer, for resting and alertness in winter. From 16:00 h to 17:00 h, during winter season, male nilgai spent maximum time for the activities which were inactive standing, locomotion, alertness, environmental sniffing and self-directed behaviour whereas during monsoon season for foraging and during summer season for resting.

Comparison of the mean percentage of hourly activity pattern of female nilgai among the three studied season from 10.00 h to 5.00 h are presented in Figure 8. When data were compared among the seasons, from 11:00 h to 12:00 h, it was observed that for foraging, drinking and feeding of offered feed, time spent was maximum during summer, for locomotion during winter and for alertness and affinitive interaction during monsoon. From 12:00 h to 13:00 h, the activities like foraging and locomotion were observed in higher frequency during monsoon than the other two seasons, while inactive standing and alertness during winter and feeding of offered feed, drinking and resting during summer. From 13:00 h to 14:00 h, time spent for the activities such as foraging, inactive standing, locomotion and alertness were the maximum during winter, whereas feeding of offered feed during monsoon and resting during summer. From 13:00 h to 14:00 h, for foraging and feeding of offered feed, higher time spent by female nilgai was noted during summer, for resting, locomotion and affinitive interaction during monsoon and for inactive standing and alertness during winter. From 14:00 h to 15:00 h, foraging, feeding of offered feed, inactive standing and locomotion were found to occur at high frequency in monsoon, while resting in winter and drinking in summer. Among the three studied season, in the last two hours of the study period foraging was maximum during summer, inactive standing, locomotion and alertness during winter and resting during monsoon.

Comparison of the mean percentage of hourly activity pattern of calf of nilgai among the three studied season from 10.00 h to 5.00 h are shown in Figure 9. When mean time spent percentage of calf was compared among seasons, from 10:00 h to 11:00 h, it was observed that feeding of offered feed and drinking were found to occur at higher rate during summer, locomotion and alertness during winter and inactive standing during monsoon. From 11:00 h to 12:00 h, foraging and resting were noted to happen in maximum frequency during summer, feeding of offered feed, inactive standing and alertness during winter and drinking and locomotion during monsoon. From 12:00 h to 13:00 h, time spent for foraging and resting was found more during summer, feeding of offered feed, inactive standing and locomotion during monsoon and alertness during winter. From 13:00 h to 14:00 h, the activities like foraging, feeding of offered feed and resting were noticed to occur in higher time spent percentage during summer, while drinking and inactive standing during winter and alertness during monsoon. From 14:00 h to 15:00 h, foraging, feeding of offered feed and drinking were maximum during summer, whereas inactive standing, locomotion and alertness during winter and resting during monsoon. From 15:00 h to

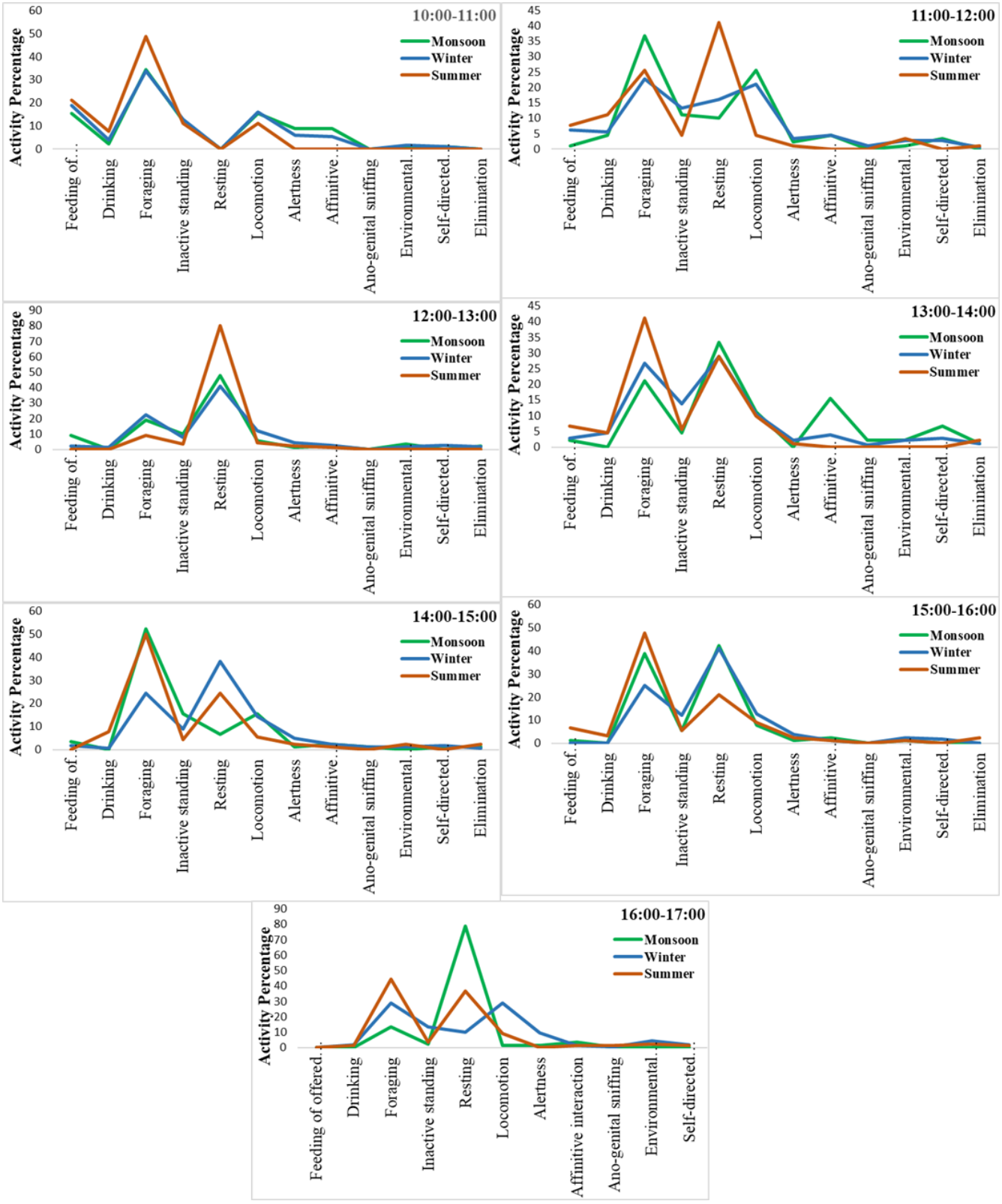

Fig. 8: Comparison of hourly activity budget among seasons in female nilgai at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

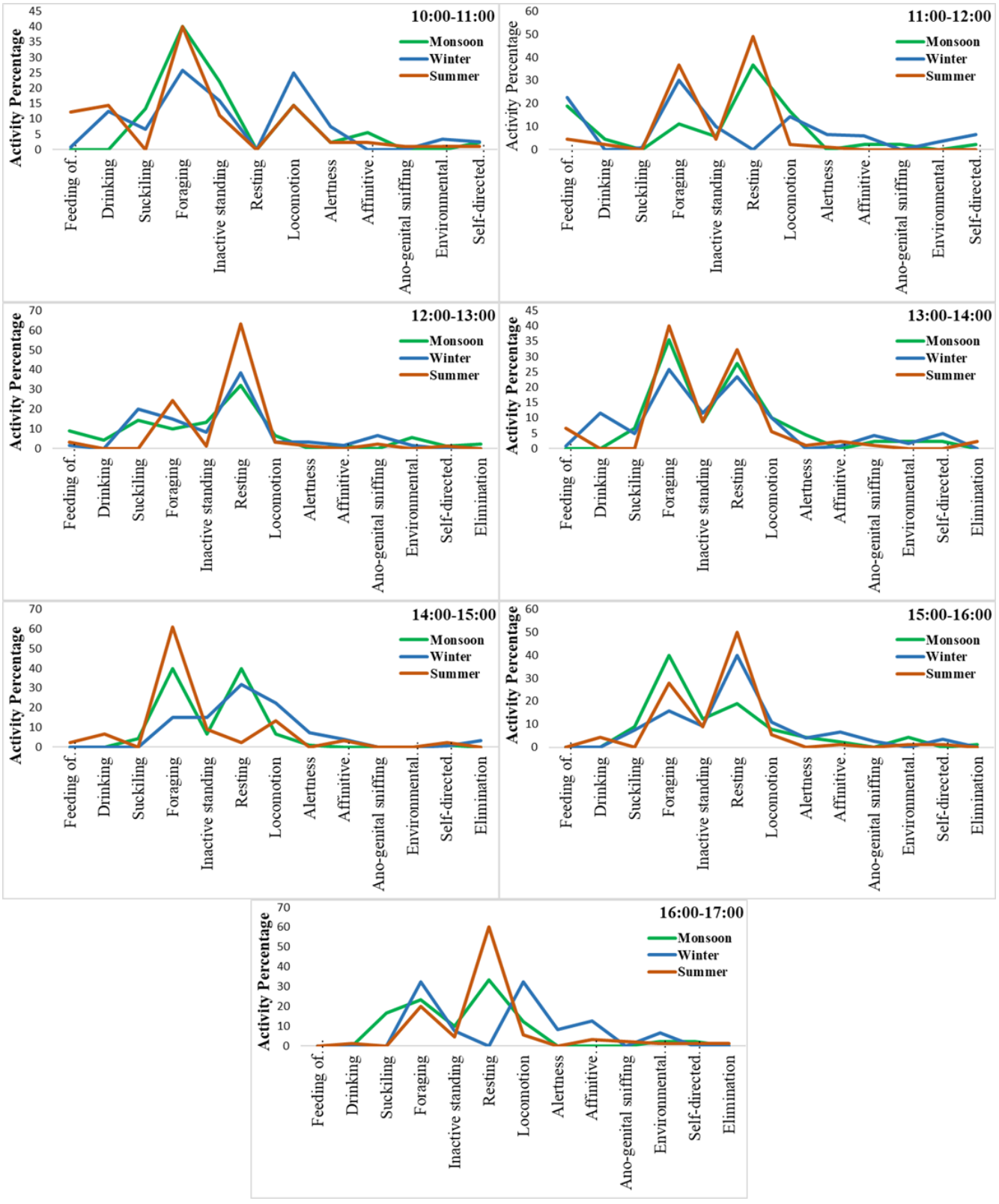

Fig. 9: Comparison of hourly activity budget among seasons in calf of nilgai at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

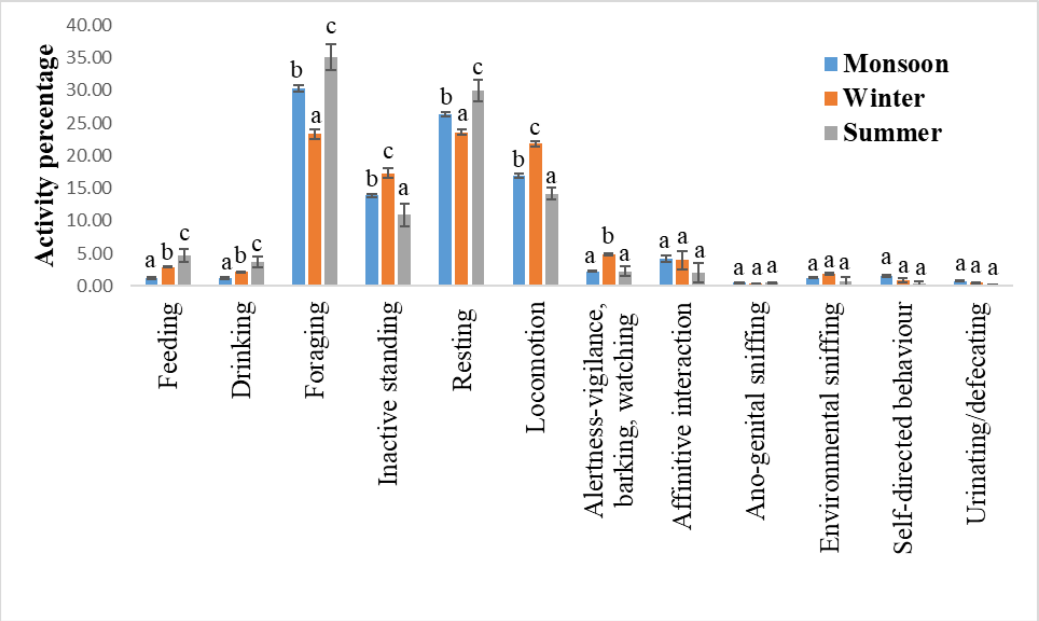

Fig. 10: Scan sampling data of activity budget of nilgai, *B. tragocamelus* at Alipore Zoological Garden. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

16:00 h, the calf spent maximum time for the activities which were foraging and inactive standing during monsoon, locomotion during winter and resting during summer. From 15:00 h to 16:00 h, time spent for foraging, locomotion and alertness were higher during winter, whereas for inactive standing during monsoon and resting during summer.

Scan sampling

In case of all the studied seasons, the most predominant behaviour of the group of nilgai (Fig. 10) in the Alipore Zoological Garden, Kolkata was foraging, followed by resting, and locomotion.

When data were compared among seasons, it was noticed that their foraging, feeding of offered grasses and resting were significantly maximum (P<0.05; DMRT) in summer, while foraging and resting were minimum in winter and feeding of offered feed and drinking in monsoon. Activities such as inactive standing, locomotion and alertness were found to occur with high rate (P<0.05; DMRT) during the winter season, while with lower rate during monsoon. The less frequent activities such as affinitive interaction, ano-genital sniffing, self-directed behaviour and urinating/ defecating were observed to occur at higher rate during monsoon and at lower rate during summer.

Discussion

There is various scattered information available, regarding the ecology and behaviour of nilgai, mainly on the food habits (Berwick, 1974; Mirza and Khan, 1975; Dinerstein, 1980; Sheffield *et al*., 1983; Haque, 1990; Sankar, 1994) and ranging pattern (Rajurohit, 1988; Kusum, 2018). Some earlier studies were performed on the behavioural pattern of blue bull in the wild (Lacey, 1969; Acharjyo and Misra, 1973; Mirza and Khan, 1975; Chitampalli, 1983; Sheffield *et al*., 1983; Oguya and Eltringham, 1991; Sankar and Vijayan, 1992; Bohra *et al*., 1992). Very few studies have been conducted on the diurnal behavioural pattern of captive nilgai (Oguya and Eltringham, 1991). Most of the investigation reports were more than twenty years old. However, a very little is known about the detailed diurnal activity time budget of nilgai. Moreover, reports on hourly activity time budget of different season as well as in the different sex classes and calf are limited or lacking.

Environmental factors, particularly weather conditions and availability of food shape the behavioural pattern of nilgai, i.e, time allocation in various activities is dependent on these factors. In the present study seasonal influence on the activity time budget of different sex classes, calf and the whole group of nilgai in Alipore Zoological Garden, Kolkata was explored using direct observation.

The Activity pattern of both the sex classes and calf of nilgai in different seasons revealed that more foraging activity occur in summer, followed by monsoon and less in winter. High foraging activity in summer might be due to least availability of grasses and in summer grasses become dry and less nutrient. This finding supports the observation of earlier reports by Gautam and Bissa (2015) and Kusum (2018). Both the male and female, and the calf allocated maximum time for resting during the summer and least time during the winter season. In summer, resting is more might be due to scorching heat wave. In contrary, Gautam and Bissa (2015) reported that resting was more in winter and less in summer. All the studied animals and also the groups showed more locomotion in winter and less in summer. This result depicted that to avoid high temperature, they preferred winter for locomotion. While a opposite trend of locomotion activity was noted by Gautam and Bissa (2015) and Kusum (2018). More time was spent in standing by the studied nilgai during winter and less in summer. Gautam and Bissa (2015) observed that standing was less in summer as found in the present study but more in monsoon. While Singh (1995) observed more standing in winter. These variations are due to variation of habitat and weather condition of that habitat (Gautam and Bissa, 2015).

Animals display a wide variety of diurnal activities, but the percentage of the activity budget shows variation due to limitation in space, food, human presence and weather condition (Hamel and Cote, 2008; Schweigher *et al*., 2015). Besides these factors, crepuscular activity rhythms and some celestial events like eclipse also have an impact on the diurnal activity budget of ungulates like nilgai (Mahato *et al*., 2013; Ensing *et al*., 2014). In the present study, foraging activity observed was the dominant activity in the activity profile for all the studied season in case of the male, female and calf of nilgai. They spent nearly half of the day in foraging, followed by resting and remaining time utilized by other activities such as locomotion, alertness, drinking, etc. Nilgai mainly feed on grasses and shrubs and they devoted a huge time for foraging to meet their daily dietary requirement which was clearly portraited in their time budget of feeding and locomotion. A similar observation was reported by Kusum (2018) that a little amount of time was spent by the nilgai on other activities compared to feeding, running, resting and standing. As blue bulls are inhabitants of tropical climatic belt, they forage or locomote more when the environmental temperature is low. The current study and many earlier studies also showed a similar trend of foraging schedule (Quasin *et al*., 2014; Pandey, 2022) and time budgeting for feeding and locomotion (Quasin *et al*., 2014; Bayani and Watve, 2016; Pandey, 2022). Maximum resting was noted in afternoon, and evening had more alertness in nilgai. A similar result was reported by other researchers (Schaller, 2009; Pandey, 2022).

The present study found a pattern of docility between female and calves which was displayed by the fact that female always grazed with calves and they are relatively social, whereas males were seen in a scattered form. This observation was in the line of earlier studies (Pandey, 2022). Another observation in daily activity budget of the current study was that the activity pattern of both the male, female nilgai and their calves was affected by human disturbances. It was indicated by the alertness activity which was found more in winter when tourist pressure was higher than the other two season in the zoo.

Hence, nilgai of Alipore Zoological Garden devoted their maximum time in the basic activities like foraging, resting and locomotion and less

amount of time in other activities. The basic activities were found to fluctuate significantly among the season, sex classes and also among the different hours of day. This observation-based results also revealed that activity pattern of nilgai was influenced by visitor pressure of zoo. This behavioural study of nilgai might be helpful in exploring the influence of captivity on their behaviour displays, which could be informative to construct more scientific enclosure or needed for the management of captive environment.

Conclusion

It is concluded that the studied nilgai and their herd divide the hours of day in different activities and their time budget revealed that they allocated major time share in foraging, followed by resting, and locomotion. Like other ungulates, they perform social behaviours. Human disturbances were found to have a significant influence on their behavioural activities. Moreover, it was evident that activity budget of nilgai were directly related to nature as the frequency of their performed activities were varied significantly among the seasons.

The results of this observation-based study on the activity budgeting of the different sex classes of nilgai and their calves, which was conducted for a longer period, will allow us to compare and analyse the behavioural patterns of the studied captive nilgai with the wild ones which would be helpful for the captive management and welfare of nationally threated nilgai.

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Conflict of Interest

The authors declare no conflicts of interest.

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