Asian Journal of Conservation Biology, July 2017. Vol. 6 No. 1, pp. 31-37 AJCB: FP0081
ISSN 2278-7666 ©*TCRP* 2017

Diurnal Activity Budgets and Activity Patterns of a Reintroduced Gaur Population in Bandhavgarh Tiger Reserve, Madhya Pradesh, Central India

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(Accepted: June 25, 2017)

ABSTRACT

The diurnal activity budgets and activity patterns of a reintroduced gaur population were studied in Bandhavgarh Tiger Reserve, Central India from March 2012 to February 2014. We observed that throughout the year feeding was the major activity of gaur followed by moving and resting. The time spent in feeding by gaur was observed to be lower in monsoon as compared to summer and winter which is likely due to the availability of higher quality of forage in monsoon. Throughout the year gaur showed a bimodal feeding pattern with the time spent feeding peaking in the early morning (0600-0800 hrs) and late afternoon-evening (1600-1800 hrs) time frames whereas the time spent resting peaked in the midday hours. Among different age/sex classes of gaur we observed that adult cow spent highest time in vigilance behaviour whereas the time spent by calf in vigilance behaviour was the lowest. The reintroduction of gaur to Bandhavgarh is the first of its kind in the entire distributional range of this species and the information generated through this study will help the park authorities in better management of this reintroduced gaur population.

Keywords: Bandhavgarh Tiger Reserve, Central India, Reintroduced gaur, Activity budgets.

INTRODUCTION

Studying the activity budgets and activity patterns of a species gives an insight into the allocation of time for different activities by the species annually and seasonally which in turn can lead to a better understanding of its general ecology. Mammalian herbivores have been observed to spend the majority of their time feeding (Beekman & Prins, 1989) and among mammals, various studies have shown that a polyphasic activity pattern which alternates between feeding and resting/ruminating activities is characteristic of ruminants (Gates & Hudson, 1983; Hudson & Watkins, 1986). The activity patterns of wild herbivores show fluctuations according to the environmental temperatures and seasonal changes in the quality and quantity of the available forage (Trudel & White, 1981; Hudson & Frank, 1987).

Gaur (*Bos gaurus gaurus*) is a member of the wild cattle group and is Asia's largest bovid species (Ahrestani & Prins, 2011). India has a substantial gaur population (23,000 approx.) (Sankar *et al*., 2001) and although quite a few long term ecological studies have been conducted on gaur in India (Schaller, 1967; Easa, 1998; Sankar *et al*., 2001; Gad, 2011, Ahrestani & Prins, 2011; Ahrestani *et al*., 2011) the published information, especially on the activity budgets of gaur is scarce. In the present study we report the diurnal activity budgets and activity patterns of a reintroduced population of gaur in Bandhavgarh Tiger Reserve (BTR), Central India.

The forests of Central India are known to harbour about 1/4th of the gaur population of India (Sankar *et al*., 2001). Among the many protected areas in the Central Indian landscape the Bandhavgarh Tiger Reserve (BTR) had a small gaur population of about 35-45 individuals which became extinct in 1998 (Pabla *et al*., 2011). Bandhavgarh Tiger Reserve was connected to other forested areas through small forest corridors and the destruction of these migratory corridors has been considered as the main reason for the disappearance of the small gaur population from BTR. As a conservation initiative, 50 gaur individuals of mixed age and sex classes were reintroduced in BTR from the Kanha Tiger Reserve (about 200 kms. away from BTR) between January 2011 and March 2012 (Pabla *et al*., 2011) which was the first reintroduction programme of wild gaur in its entire distributional range. In any reintroduction programme the monitoring and undertaking of ecological studies of the reintroduced species is of vital importance (IUCN, 1998) and the present study is a part of an intensive monitoring programme of the reintroduced gaur population which started in January 2011 and is still on-going.

MATERIALS AND METHODS

Study area

Bandhavgarh Tiger Reserve (23°30' 08" to 23°47' 05" N and 80°11' 43" to 80°47' 05" E) lies in the state of

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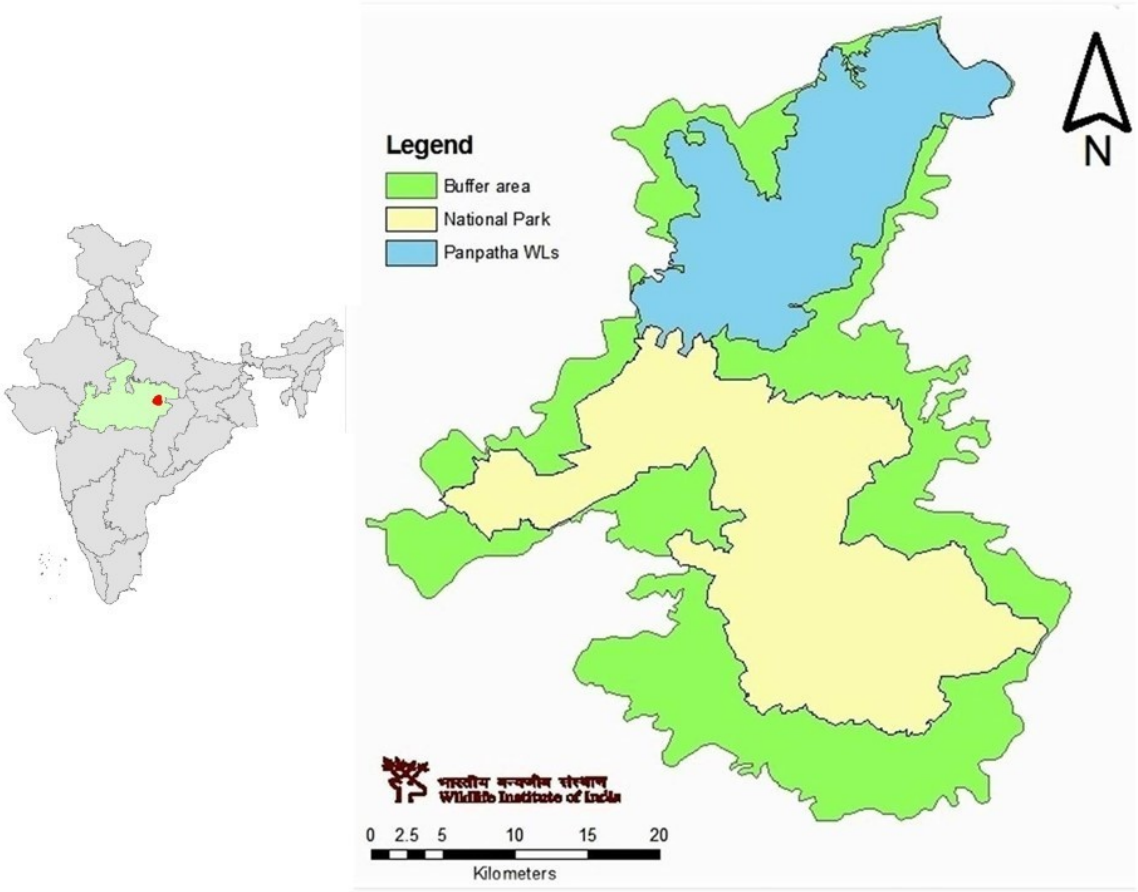

Figure 1. Study Area: Bandhavgarh Tiger Reserve, Madhya Pradesh, Central India

Madhya Pradesh, Central India, on the northern flanks of the eastern Satpura Mountain range (Sankar *et al*., 2013). Two protected areas together comprise the BTR, viz. Bandhavgarh National Park (442.8 km^2) and the Panpatha Wildlife Sanctuary (245.8 km^2) (Sankar *et al*., 2013) (Fig. 1). The terrain in BTR is extremely rugged with small hillocks interspersed with grassy swamps (Gopal, 1991) and since the rock formations in BTR comprise mainly of sandstone, which is a well-known aquifer, many areas in BTR have a high water table which has resulted in the reserve having a lot of perennial and seasonal streams and rivulets (Lad & Gopal, 1992; Prakasam, 2006). BTR lies in the tropical zone and has three distinct seasons viz. summer (March-June), monsoon (July-October) and winter (November-February). The average rainfall in BTR is 1,173 mm and most of it is received in the monsoon (Sonakiya, 1993; Sankar *et al*., 2013). According to the vegetation classification of Champion and Seth (1968) the vegetation in BTR falls under Moist peninsular low level sal (*Shorea robusta*) forest, Northern dry mixed deciduous forest, Dry deciduous scrub, Dry grassland and West Gangetic moist mixed deciduous forest.

Procedures

For the collection of data on activity patterns of gaur the scan sampling technique (Altman, 1974) was used. Of the entire reintroduced gaur population (n=50) a total of 27 individuals were radio collared and hence different gaur herds were tracked using radio telemetry. When a gaur herd was sighted, scan samples were recorded at five minute intervals and the activities of all animals visible at that time were recorded. The observation time was of five minutes followed by an interval of five minutes which amounted to six scans per hour. In each scan the age and sex class of the gaur individual and the activity were recorded. The activity data on gaur was collected every month from March 2012 to February 2014 and in a month the activity data was collected from 0600 hrs in the morning to 1800 hrs in the evening. The observations were made from vehicle (open top four wheel drive vehicle) and on foot.

In a gaur herd the individuals were classified into seven different age/sex classes based on the works of Schaller (1967), Sankar *et al*. (2001) and Ahrestani and Prins (2011) as follows:

***Adult cow*:** A full grown adult cow stands at shoulder up to 1.5 m on an average, dewlap and the dorsal ridge are less prominent; *Black bull*: Bull with black pelage and larger in size than adult cow, prominent dewlap and dorsal ridge; *Brown bull*: Bull which is almost the size and colour of adult cow; *Sub adult cow*: Smaller, less bulky than adult cow and ¾ the size of adult cow; *Sub adult bull*: Smaller, less bulky than adult cow and ¾ the size of adult cow; *Yearling*: About 2/3 the size of adult cow; *Calf*: Quarter the size of adult cow.

The activities recorded for gaur during the present study were:

***Feeding*:** The animals feed on various type of plant material; *Standing*: The animals just stand (may ruminate

during standing); *Moving*: The animals move from one place to another; *Resting*: The animals generally sit in shade (many a times ruminate) and might also sleep by resting their head on the ground; *Vigilance behaviour*: The animals raise their head up and look in a particular direction generally with their ears raised. Other activities recorded were Allogrooming, Autogrooming, Sexual behaviour, Aggressive behaviour, Vocalisation, Salt licking, Drinking, Defecating and Urinating.

Data Analysis

The percentage time spent in each activity by gaur individuals from the seven different age/sex classes was calculated from the scan sampling data. The data for all the age/sex classes of gaur was pooled together to calculate the percentage time spent in different activities by gaur in general. The annual and seasonal activity patterns and activity budgets were calculated for gaur in general. For the analysis of annual activity budgets and activity patterns the data for the entire study period (six seasons) was pooled together. For the analysis of activity pattern the entire day (0600-1800 hrs) was divided in six time frames of two hours each viz. 0600-0800, 0800-1000, 1000-1200, 1200-1400, 1400-1600 and 1600-1800 hrs. As rain and temperature has an effect on activity (Joshua, 1992), the entire year was divided into three seasons viz. summer (March-June), monsoon (July-October) and winter (November-February).

The statistical package SPSS was used for data analysis (Norusis, 1993). The data was tested for normality (Siegel, 1956) and since the data was found to be non-normal, the non-parametric Kruskal-Wallis test (Siegel, 1956) was used to analyse the data. Percentage time spent on major activities like feeding, standing, moving, resting and vigilance behaviour by gaur in general was tested for significant difference across the seasons. Percentage time spent annually in activities like feeding, standing, moving, resting and vigilance behaviour was tested for significant difference among different age/sex classes of gaur.

RESULTS

A total of 17,330 scan records were obtained for gaur during the study period. The number of scan records were more in summer (6,932) as compared to monsoon (5,810) and winter (4,588) because of greater visibility in the forest due to leaf shedding and less understory growth in summer. The diurnal annual activity budget of gaur (Fig. 2) showed that the major activities of gaur throughout the day were feeding, moving, resting and standing. The percentage time spent by gaur in feeding, moving, resting and standing was 38.8%, 24.4%, 20.4 % and 10.8% respectively, thus for gaur about 94.4% of the time in the day was occupied in these four activities. Apart from that, the time spent by gaur on vigilance behaviour was 1.5% whereas the rest 4.1% time was spent in other activities like drinking, allogrooming, autogrooming and other social interactions like sexual behaviour and aggressive behaviour.

Fig. 3 shows the percentage time spent by gaur in four major activities across three seasons. The percentage time spent in feeding was highest in summer (42.5%) compared to monsoon (34%) and winter (39.7%) and the difference was found to be significant (χ^2=11.35, p<0.05). The time spent in standing was significantly higher in winter (13.2%) compared to summer (9.2%) and monsoon (10%) (χ^2 =7.30, p<0.05). Gaur spent 28.3% of the time moving in winter compared to 19.4% in summer and 25.6% in monsoon and the difference was found to be significant (χ^2 =45.31, p<0.05). The time spent resting by gaur in winter (14.7%) was significantly lower compared to summer (23.8%) and monsoon (22.9%) (χ^2=38.28, p<0.05).

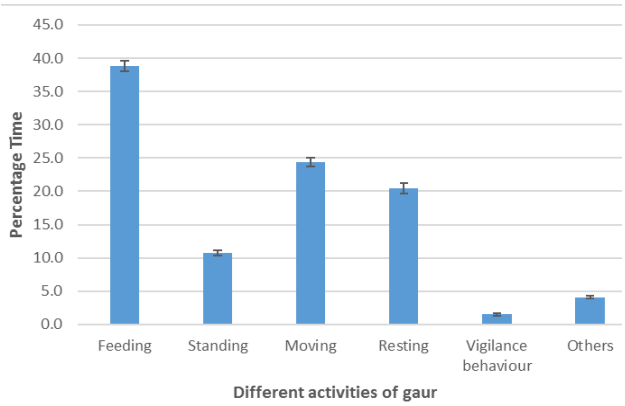

Figure 2. Diurnal annual activity budget of gaur in Bandhavgarh Tiger Reserve (March 2012-February 2014).

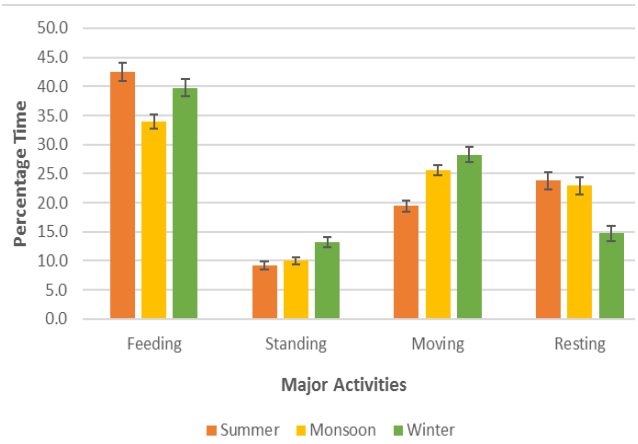

Figure 3. Time spent in major activities by gaur in different seasons in Bandhavgarh Tiger Reserve (March 2012-February 2014).

Fig. 4 shows the percentage time spent by gaur in vigilance behaviour across three seasons. The percentage time spent in vigilance behaviour by gaur was observed to be higher in monsoon (2.1%) as compared to summer and winter (1.3% and 1.2% respectively) but the difference was observed to be non-significant across the seasons (χ^2 =5.61, p>0.05).

The percentage time spent annually in activities like feeding, standing, moving, resting and vigilance behaviour by different age/sex classes of gaur is given in table 1. Time spent feeding annually was found to differ significantly among the different age/sex classes of gaur

Table 1. Time spent annually in major activities by different age/sex classes of gaur in Bandhavgarh Tiger Reserve (March 2012-February 2014)

Activities	Age/sex classes of gaur						
	Adult cow	Sub-adult cow	Yearling	Black bull	Brown bull	Calf	Sub-adult bull
Feeding	42.7 (1.7)	42.4 (1.8)	35.2 (2.4)	36.2 (2.8)	37.3 (3.8)	29.6 (1.7)	45.1 (2.3)
Standing	10.3 (0.7)	8.8 (0.8)	14.2 (1.6)	8.3 (1.1)	8.0 (1.4)	14.8 (1.2)	9.3 (1.2)
Moving	21.4 (1.1)	24.3 (1.3)	25.7 (1.9)	25.3 (2.2)	25.9 (3.2)	27.7 (1.6)	22.5 (1.7)
Resting	20.2 (1.7)	18.7 (1.8)	19.4 (2.2)	22.5 (2.9)	24.0 (3.7)	23.7 (2.1)	16.8 (2.1)
Vigilance Behaviour	2.5 (0.4)	1.8 (0.3)	1.1 (0.4)	0.9 (0.3)	0.9 (0.4)	0.4 (0.1)	2.2 (0.7)

[a]Standard errors are mentioned in parentheses.

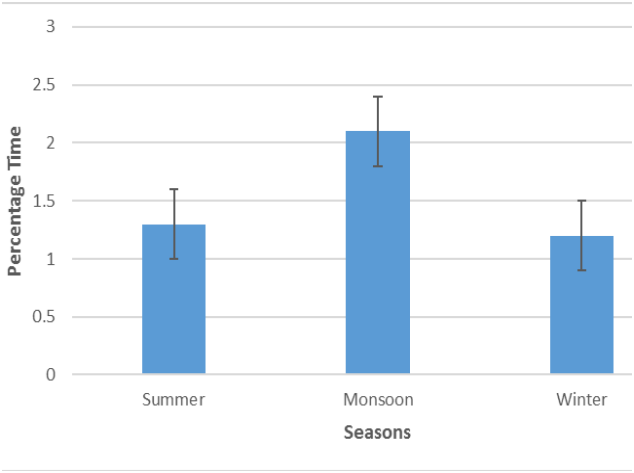

Figure 4. Time spent in vigilance behaviour by gaur in different seasons in Bandhavgarh Tiger Reserve (March 2012-February 2014).

(χ^2 =44.43, p<0.05). Annually the time spent feeding was highest for sub-adult bull (45.1%) and was lowest for calf (29.6%). The time spent standing was found to differ significantly among different age/sex classes of gaur (χ^2 =38.65, p<0.05). The time spent standing annually was observed to be the highest for calf (14.8%) and lowest for brown bull (8%). No significant difference was observed in time spent for moving (χ^2 =7.03, p>0.05) and resting (χ^2 =8.39, p>0.05) activities annually among different age/sex classes of gaur. Annually the time spent moving was observed to be highest for calf (27.7%) and lowest for adult cow (21.4%) and time spent resting was observed to be highest for brown bull (24%) and lowest for sub-adult bull (16.8%). The percent time spent in vigilance behaviour was found to be highest for adult cow (2.5%) followed by sub-adult bull (2.2%) and sub-adult cow (1.8%). The difference in time spent in vigilance behaviour annually by different age/sex classes of gaur was found to be significant (χ^2 =42.38, p<0.05).

The annual and seasonal major activity patterns of gaur are given in Fig. 5, 6, 7 and 8. The annual major activity pattern of gaur (Fig. 5) showed that the feeding activity peaked in the early morning hours (0600-0800 hrs) and in the late afternoon-evening hours (1600-1800 hrs). The feeding activity was observed to be at its lowest in the time frame of 1000-1200 hrs when the resting activity was at its peak. The time spent moving by gaur was observed to be highest in the early morning time frame (0600-0800 hrs) after which it steadily declined till 1200 hrs and then did not show much variation. Overall the time spent in standing by gaur was observed to be higher in the time frames of 0600-1200 hrs as compared to time frames of 1200-1800 hrs.

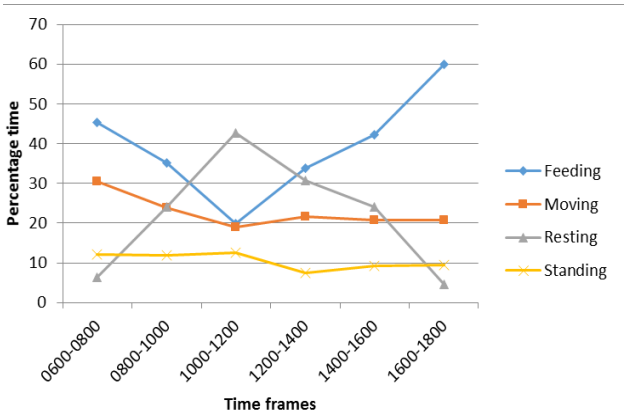

Figure 5. Annual major activity patterns of gaur in Bandhavgarh Tiger Reserve (March 2012-February 2014).

Seasonally, the major activities of gaur showed a similar pattern to that of the annual activity pattern. Feeding activity showed a bimodal pattern in all the seasons wherein it showed two peaks, one in the early morning time frame (0600-0800 hrs) and other in the late afternoon-evening time frame (1600-1800 hrs). In summer and winter (Fig. 6 & 7) the time spent in resting was highest in the time frame of 1000-1200 hrs whereas in monsoon it was highest in the time frame of 1200-1400 hrs. The moving activity by gaur showed a similar pattern for summer and monsoon wherein the time spent in moving was highest in the early morning time frame after which it declined in the midday hours and showed an increase again in the late afternoon time frames. In winter the moving activity was observed to peak in the time frames of 1000-1200 hrs and 1200-1400 hrs (Fig. 8).

DISCUSSION

This study showed that throughout the year the major activities of gaur were feeding, moving, resting and

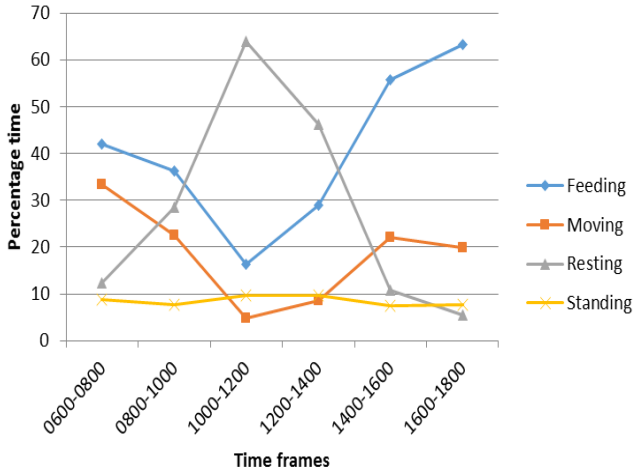

Figure 6. Major activity patterns of gaur during summer in Bandhavgarh Tiger Reserve (March 2012-February 2014).

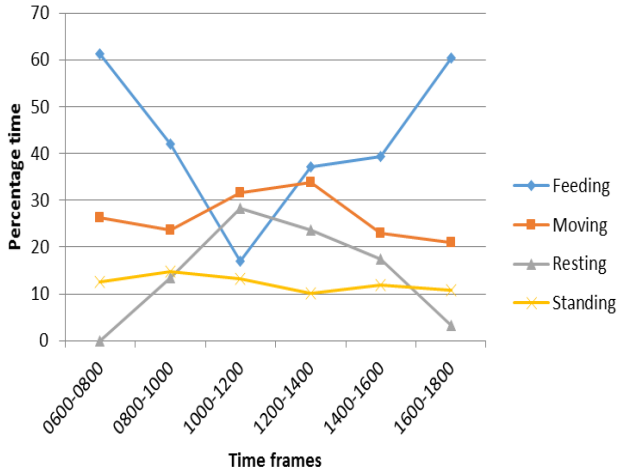

Figure 8. Major activity patterns of gaur during winter in Bandhavgarh Tiger Reserve (March 2012-February 2014).

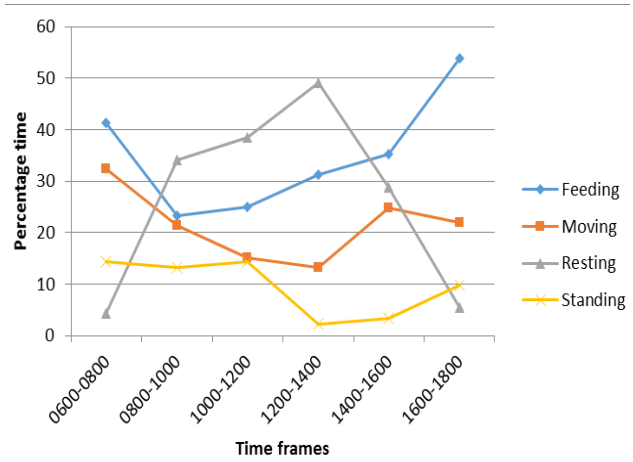

Figure 7. Major activity patterns of gaur during monsoon in Bandhavgarh Tiger Reserve (March 2012-February 2014).

standing. Similar findings were reported by Easa (1998) and Gad (2011) for gaur from Parambikulam Tiger Reserve and Bhagwan Mahaveer Wildlife Sanctuary respectively in the Western Ghats region of India. Various studies on mammalian herbivores have shown that feeding is the major activity throughout the day (Tyler, 1972; Pratt *et al*., 1986; Prins, 1996; Stobbs, 1970; Beekman & Prins, 1989) and our observations also showed that the time spent in the feeding activity by gaur was the highest in all the seasons. Easa (1998) reported an annual feeding time of 63.4% for gaur in Parambikulam which is higher as compared to the present study but the total time spent in feeding, moving and resting comprised 88.5% of the diurnal annual activity budget of gaur in Parambikulam (Easa 1998) which is similar to the observations of the present study. Among other species of the Bovini tribe, for African buffalo *Syncerus caffer*, Ryan and Jordaan (2005) reported an average diurnal feeding time of 37.5% whereas an average diurnal feeding time in the range of 25% to 33.3% has been reported by Grimsdell (1969).

We observed that the feeding time for gaur was lower in monsoon as compared to summer and winter. This is likely due to the availability of forage of higher nutritional quality in monsoon which allows the gaur to fulfil their nutritional requirements with lower feeding time as compared to summer and winter. A similar trend has been reported for the African buffalo by Prins (1996) and Ryan and Jordaan (2005). Annually the time spent feeding showed significant difference among different age/sex classes of gaur since the energy requirements of each age/sex class differ. Annually, highest time spent feeding was observed for sub-adult bull followed by adult cow and sub-adult cow. In herbivores, sub-adult individuals are expected to forage for a longer time owing to their higher energy demands (Ruckstuhl & Neuhaus, 2009) and this seemed to be the case among the sub-adult gaur individuals. The feeding time for adult cow was high probably because of pregnancy and lactation pressures. The reason for adult bulls (black and brown bulls) spending less time for feeding as compared to adult cow and sub-adults may be that when in a herd, adult bulls spend a considerable time in searching for and tending to cows in oestrus and looking out for potential competitors (Schaller, 1967; Sankar *et al*., 2001). Adult bulls also spent a considerable time ranging as bachelor bulls (either solitary or in an all male herd). We could obtain only a few observations of bachelor bulls; for instance, of the total number of scan records for brown and black bulls (n=693 and n=793 respectively) only 72 and 26 scan records were made for bachelor brown and black bulls respectively. The analysis of these scan records separately showed that when in a bachelor status the percentage feeding time for brown bulls and black bulls was 75% and 72.2% respectively. Thus, it seems that adult gaur bulls spend a considerably higher time feeding when in a bachelor state as compared to that when in a mixed herd (But more data needs to be collected on this aspect of gaur behaviour). Adult males joining mixed herds and getting separated from them (bachelor state) is a phenomenon observed in many ungulate species (Prins, 1989).

The annual and the seasonal activity patterns of gaur showed that feeding activity peaked in the early morning and late afternoon-evening hours whereas the resting activity was most prominent during the mid-day hours. Similar activity pattern for gaur has been reported from Mudumalai, Parambikulam, Pench and Periyar Tiger Reserves and Bhagwan Mahaveer and Kuldiha Wildlife Sanctuaries (Krishnan, 1972; Easa, 1998; Sankar *et al*., 2001; Valappil, 2000; Gad, 2011; Nayak & Patra, 2015). Also, a similar activity pattern was reported by Lad and Gopal (1992) for the small gaur population in Bandhavgarh prior to its extinction. Apart from gaur a similar activity pattern has been reported for African buffalo by Ryan and Jordaan (2005) from the Kruger National Park, South Africa. It was observed from the seasonal activity budgets and activity patterns that the percentage time spent in resting by gaur was lower in winter as compared to the other two seasons. This seems to be in response to the lower heat stress in winter (mean monthly temp. range: 10.2°C to 19.1°C) than that in summer (mean monthly temp. range: 27.2°C to 43.8°C) and monsoon (mean monthly temp. range: 23.8°C to 33.3°C) observed during the present study.

The percentage time spent moving in summer was observed to be lower than that in monsoon and winter. In summer the food resources for gaur are probably more confined on a spatial scale than in the other seasons which may be the reason for gaur spending less overall time moving in summer. We observed that adult cow spent the highest time in vigilance behaviour followed by sub-adult bull and sub-adult cow. The time spent in vigilance behaviour was found to be lowest for calf. Adult cows had to care for their calves and yearlings which might be the main reason for adult cows spending more time in vigilance behaviour as compared to other age/sex classes of gaur. After adult cow, the age class with more time spent in vigilance behaviour was the sub-adult age class. In a gaur herd, calves, yearlings and sub-adult individuals are more vulnerable to predation as compared to adult animals (Schaller, 1967) and this probably leads the sub-adult gaur spending a higher time in vigilance behaviour. Yearlings and calves tend to stay close to the mother cow which might be the reason for individuals in these age classes spending less time in vigilance behaviour.

CONCLUSION

The results of this study showed that the activity pattern of gaur in Bandhavgarh Tiger Reserve is similar to other gaur populations from various protected areas in India and hence being relocated to a new place does not seem to have affected the behaviour of these animals. In the present study we were not able to make nocturnal observations but Schaller (1967) and Lad and Gopal (1992) mentioned about gaur continuing to feed during the night. Various studies on related species like the African buffalo, American and European Bison have reported a high percentage of time spent feeding during the night interspersed by resting bouts (Prins, 1996; Ryan & Jordaan 2005; Cabon-Raczynska, Krasinska and Krasinski, 1983 and Cabon-Raczynska *et al*., 1987) and it is highly likely that gaur also follow a similar pattern. The reintroduction of gaur in Bandhavgarh Tiger Reserve is an important conservation initiative for this species and proper management of this reintroduced population in future will determine the long-term success of this endeavour and hence the information generated through this study will be useful for the park management for the conservation and management of this reintroduced gaur population.

ACKNOWLEDGEMENTS

We would like to thank the Field Director, Deputy Director and the entire staff of the Bandhavgarh Tiger Reserve, Madhya Pradesh, for their continued support and cooperation during this study. We are indebted to our field assistants Umesh, Gopal and Shrivastav for their dedicated efforts in tracking gaur and overall assistance during the field work. We are grateful to Director and Dean, Wildlife Institute of India, Dehradun for their guidance and support extended during the study and thank Madhya Pradesh Forest Department for the funding support provided to the project.

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