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Behavioral Ecology of Spotted deer (Axis axis) in Parambikulam Tiger Reserve, Kerala, India

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Abstract
The impact of animal behavior on ecosystem and the animal populations are well acknowledged, however, the influence of these behavior on several ecological events are understudied. Ungulates represents a critical component of terrestrial ecosystem, whose abundance and foraging behaviour can influence the animal and plant communities. The Spotted deer (Axix axis) provide an excellent model for investigating these ecological phenomena since they face differential predation risks and exhibit a fission-fusion social structure. The Spotted deer population of Parambikulam Tiger Reserve (PKTR), was investigated and the activity patterns were recorded following instantaneous scan sampling with respect to the sex and seasons. The major activity was classified as feeding, drinking, moving, resting, breeding and other activities, where feeding was recorded as the major activity and the least was reported as drinking.
Keywords: *Spotted dear, Axis axis, activity pattern, Parambikulam Tiger Reserve*

INTRODUCTION

The response of the animal to the environmental cues determines the most influential factors governing activity patterns in the deer, however, it is dependent on the tolerance level of species towards these factors (Martin, 1977). To understand the foraging and survival strategies in a habitat, the information of activity pattern is essential. Deer allocates their time and use available habitats to satisfy basic requirements for food, rumination, movement, social, interactions and rest. Abiotic factors are also considered to have a great influence on activity patterns. Activity patterns are expected to differ according to the age and sex of the animal. (Staines et al., 1982).

The time budget considers the distribution of time and the moment in which each animal displays different behaviors according to the environmental conditions. It varies seasonally according to the light hours, temperature and food availability (Xiang et al., 2010). Ungulates modify their time budget according to their physiological requirements. For example, the time spent moving and standing is greater during the breeding season than during other seasons (Brivio et al., 2010). The time budget and habitat use may vary with age, sex, time of the day, the seasonal and weather conditions. In the entire period of a day the wild animals exhibit changes in their behavior (Pipia et al., 2008). The activity pattern changes indicate crucial dimensions in the ecological niche and has been known to be directly influencing individual fitness (Kronfeld-Schor and Dayan, 2008). Spotted deer are definitely considered as an important herbivore in food chain (Eisenberg and Lockhart, 1972; Dinerstein, 1980; Sankar 1994). As ungulates are sexually dimorphic, different activity patterns have been reported. In red deer, males are considerably larger than females, exhibiting sexual dimorphism, where male and female shows differences in habitat, and space usage (Staines et al., 1982). The European roe deer are not sexually dimorphic, but males and females have different activities in their habitats, which cause to sex specific differences in the home range size (Mysterud, 1998), difference in habitat preference (Cimino & Lovari, 2003) and difference in activity pattern (Ellenberg 1978; Schober et al., 1995). This is a common among many ungulate species in different areas. The activity patterns of ungulates are influenced by many endogenous and exogenous factors. The changing azimuth of the sun, which divides day and night is the strongest exogenous factor that causes seasons (Nielsen, 1984). Temperature and rainfall and notably snow depth are the other exogenous factors (Danilkin & Hewison, 1996). The European roe deer showed two activity peaks at dusk and dawn. Seasonal variations in their activity patterns are also noticed (Ellenberg, 1978). In North America the elk behavior is strongly influenced by wolves (Canis lupus) mainly affecting vigilance, movement, and feeding pattern of elk (Childress and Lung, 2003). Considering the knowledge gap regarding the behavioral patterns of A. axis, the present study aims to understand such behavioral patterns in the A. axis population in Parambikulam Tiger Reserve, Kerala, India which not only improve our understanding on the ungulate behaviour but only contributes to develop management strategies of this species.

MATERIALS AND METHODS

The study was conducted from 1997 to 1999 in the Parambikulam Tiger Reserve which is situated in Palakkad district in Kerala state (between 76^0 35' and $76^0$50 E and between $10^0$20' and $10^0$2 6'N). This sanctuary has different natural forest types that can be classified into evergreen, semi-evergreen, moist deciduous forests, grasslands and teak plantations. The data on activity patterns were collected through instantaneous scan sampling (Altmann, 1974). Since animals were observed in groups, the observation period was 10 minutes with an interval of 5 minutes. Four samples were taken in an hour. The observation was started when the sightings of the animal groups occurred and observed when sunlight favored visibility or the animal was disturbed or the animals left the location for some reason. When the animals were found to be disturbed by the observer, the sampling was stopped and was restarted after the animal groups settled. The animals in the group were classified into sex categories. Activities of the animals recorded were classified as feeding, drinking, moving, resting, breeding and other activities (Fig. 1). The data on diurnal activity pattern of spotted deer were subjected to statistical analysis using HILOGLINEAR procedure of SPSS/PC+ for testing the seasonal variation in different activities by different age and sex categories. The HILOGLINEAR backward elimination procedure was used to test the hourly seasonal changes in different activities by different age and sex categories. Chi-square test was carried out using SPSS/PC+ CROSS TAB procedure to find the differences in frequency distribution of different activities in time budget between different age and sex categories (3 x 6 contingency table). Time budget for each activity by different age sex categories was also subjected to χ^2 test.

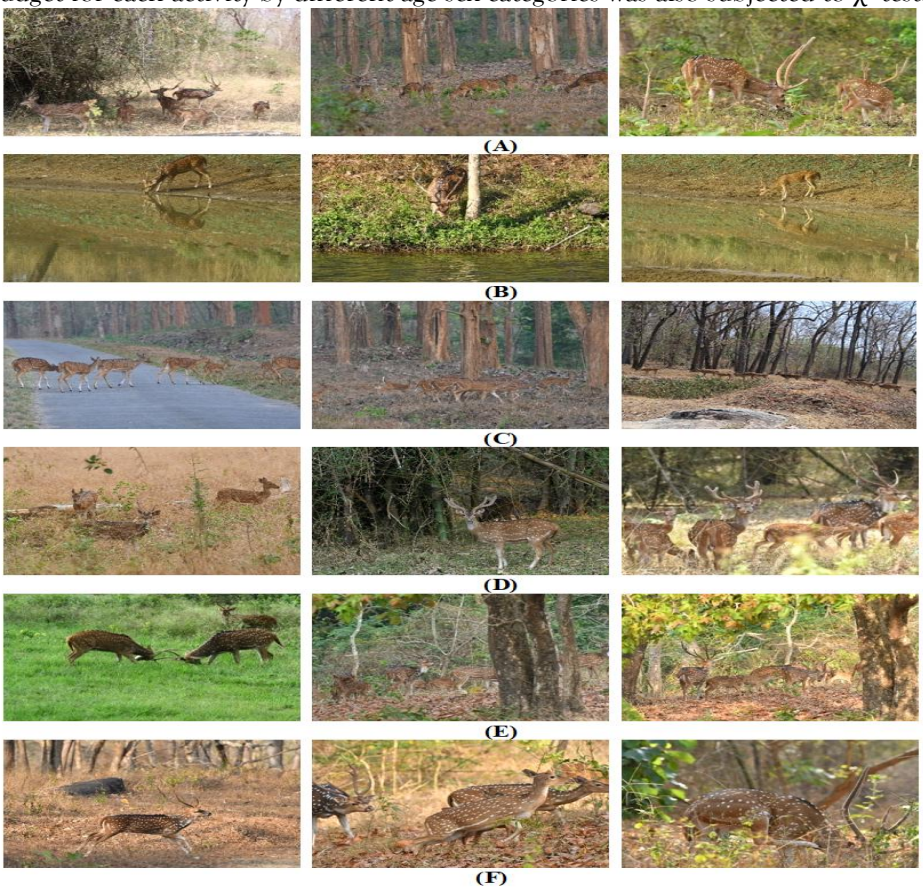

Figure 1. Photographs showing different activity patterns of spotted deer (Axis axis) (A) Feeding (B) Drinking (C) Moving (D) Resting (E) Breeding (F) Other activities

RESULTS

The major activities of male spotted deer were analysed and recorded (Table 1 – 4; Fig. 4). The major activity was feeding. The mean frequency of hours scanned for feeding was (15.87± 3.60). The mean frequency of hours scanned for drinking was minimum (1.27± 0.80). Resting was the second highest activity of A. axis (9.67± 3.66). Moving was recorded a mean scanning hour of (4.87 ± 2.33), Breeding (1.87± 2.20). Other activities (2.27±1.87) (Table 1). The different activities and different seasons showed significant differences in ANOVA (Table 2).

Table 1. Activity pattern analysis of male A. axis in different seasons (*P< 0.05, ** P< 0.01).

Activity	Winter		Dry		Wet		Overall		F-Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Feeding	14.60	1.82	20.00	2.45	13.00	1.58	15.87	3.60	38.479**
Drinking	1.20	0.45	2.00	0.71	0.60	0.55	1.27	0.80	16.650**
Moving	4.40	1.82	7.40	1.14	2.80	0.84	4.87	2.33	34.724**
Resting	12.20	1.64	5.00	1.22	11.80	1.30	9.67	3.66	93.661**
Breeding	1.60	1.52	0.40	0.55	4.60	0.55	1.87	2.20	65.308**
Other activities	1.62	0.89	4.20	1.92	1.00	0.71	2.27	187.00	19.532**

Table 2. Two way ANOVA of activity pattern of male A. axis in different seasons (*P< 0.05, ** P< 0.01)

	Sum of squares	dF	Means square	F value
Main effects (combined)	2925.30	17	172.08	97.096**
Habitats	2482.50	5	496.50	280.160**
Season	45.07	2	22.53	12.715**
2-way interactions (Hair & season)	397.73	10	39.77	22.443**
Model	3204.10	1	3204.10	1808.00**
Residual	127.60	72	1.77	
Total	6257.00	90		

*P<0.05 **P<0.01

The activity pattern of female spotted deer was analysed (Table 3). The analysis showed that the major activity was feeding 15.71± 3.60). The least activity recorded was drinking (1.32 ± 0.80), resting (4.22± 3.71), moving (4.90± 2.33), breeding (1.72± 2.12) and other activities (2.32±1.72). Two-way ANOVA of the activity pattern of the female A. axis in different seasons was performed. There were significant variations among different seasons and different activities (Table 4).

Table 3. Activity pattern of female A. axis in different seasons. *P< 0.05 ** P< 0.01

Prey Animals	Winter		Dry		Wet		Overall		F-Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Feeding	1.11	1.72	22.11	2.11	11.23	1.51	15.71	3.60	42.413**
Drinking	1.33	0.52	2.11	0.82	0.62	0.58	1.32	0.80	16.675**
Moving	4.12	1.73	7.48	1.14	2.72	0.82	4.90	2.33	32.116*
Resting	10.20	1.51	5.72	1.32	11.81	1.21	4.22	3.71	98.782**
Breeding	1.55	1.58	0.40	0.56	3.72	0.59	1.72	2.12	70.361**
Other activities	1.56	0.72	5.21	1.81	1.21	0.82	2.32	1.72	21.624**

Table 4. Two way ANOVA of activity pattern of female A. axis in different seasons. *P<0.05 **P<0.01

	Sum of squares	dF	Means square	F value
Main effects (combined)	2034.30	12	180.80	95.086**
Habitats	2082.50	8	442.58	260.147**
Season	38.07	7	18.42	11.812**
2-way interactions (Hair & season)	298.73	9	40.67	18.473**
Model	2914.18	2	3004.78	1724.000**
Residual	130.60	80	2.01	
Total	5877.00	75		

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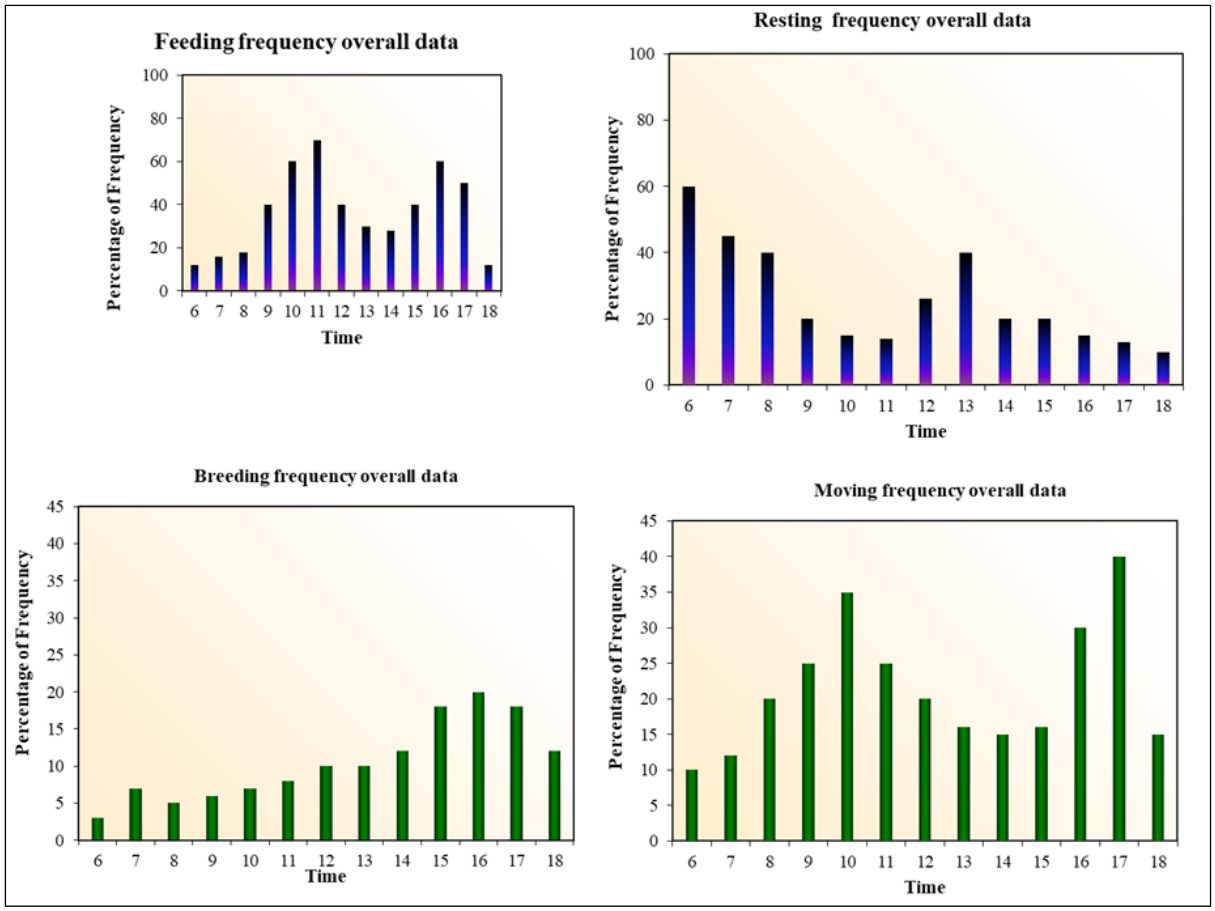

Figure 2. Average frequencies of activities of A. axis

DISCUSSION

In a wild habitat the survival of an animal exists on the time allocated to behaviours controlling either animal's chance of avoiding predation or its energy acquisition rate (Caraco, 1979). Therefore, the major activity was reported to be feeding in natural population (Rozin, 1976; Panksepp, 1974). In many of the wild ungulates the daily activity rhythm, the feeding bouts interspersed with other activities. In Parambikulam Tiger Reserve, moving activities were found interspersed with feeding activities. Seasonal differences were also noticed in dry, wet and winter seasons (Table 1 & 3). In Prambikulam Tiger Reserve, feeding was the more prominent activity in all seasons. (Table 1 & 3). The spotted deer spent half of its time for feeding and resting and moving was other major activities (Table 1 & 3). Significant seasonal variations were also observed in the feeding time. Similar observations were also reported on gaur in Mudumalai (Krishnan, 1972). In dry seasons the food patches were not found nearby and the food plants were not clumped which forced them to spent more time for feeding in dry season. In wet season, the food was more clumped and easily available and the feeding time was thus found to be reduced in wet season. Moving activity was found to be more in dry season (Table 1 & 3) due to the scattered and less clumped food plants. As the food plants was not aggregated, the spotted deer forced to spent more time moving in search of food.

Feeding constitutes the major component of all activities in natural population (Rozin 1976). Majority of wild ungulates are with many phases of daily activity rhythm in which feeding bouts are interspersed with other activity (Easa 1998). In Parambikulam Tiger Reserve spotted deer shows such type of activity patterns. Mainly feeding bouts are noticed after a resting period and moving period interspersed. Spotted deer shows a polyphase were feeding is interspersed with resting and moving. Feeding and moving occurred almost throughout in between resting (Fig. 2).

Synchronisation in activity patterns have been reported in many ungulates (Mitchell, 1977, Leuthold and Leuthold, 1978). The study in Parambikulam Tiger Reserve showed synchronisation of feeding in the morning and evening periods. The feeding activities have two peaks, one around 11 am and other around 4 pm (Fig. 2). Herds of spotted deer maximise their feeding activity in the morning and evening time in order to escape from Solar radiations and sunlight. Resting was observed mainly in morning hours and afternoon hours (Fig. 2). One around 6 PM and another around 1 PM (Fig. 2). This is also to avoid harsh

weather in the day time. These observations showed an agreement with the study of Cabon-Raczynska et al. (1983) on European bison. The European roe deer showed two activity peaks at dusk and dawn. Seasonal variations in their activity patterns are also noticed (Ellenberg,1978).

Animals displays different behaviours according to the environmental conditions. It varies seasonally according to the light hours, temperature and food availability (Xiang et al., 2010). The precipitation, temperature, food availability, water availability, predation pressure was changed according to the seasons. In the dry season the resting activity was reduced due to the increased feeding and moving in order to fulfil the nutrient requirements (Table 1 & 2). Due to the increased heat and excessive sweating, the spotted deer spent more time for drinking in dry season. In wet seasons and winter seasons only one time drinking was noticed. But in the dry seasons, more than one time drinking was noticed.

The animals may differ in their activity patterns with respect to its physiological condition (Crawley, 1983). The male and female spotted deer showed different types of activity patterns (Table 1 & 2). Spotted deer are sexually dimorphic with males considerably larger than females that also reflected in the sexual differences in activity patterns, which is seen in many ungulate species throughout the world (Ruckstuhl and Neuhaus,2002). The activity pattern and habitat use may vary with age and sex (Beier and McCullough, 1990). The physiology and mode of living is different among males and females. These differences reflected in the activity patterns also. The overall activities of male and female were found to be different (Table 1 & 2). Female spent more time in feeding than male. This may be due to the more requirement of nutrients for gestation and lactation periods. In red deer, male and females shows differences in habitat and space usage, so different activity pattern will be expected (Clutton-Brock et al,1982, Staines et al,1982).

Breeding activities were found mostly in evening hours (Fig. 2). After feeding and resting, in the evening time the spotted deer were performing breeding activities. Because the primary needs were found to be feeding and resting. Except in the dry season, the spotted deer found to be not moving much. The time spent moving and standing is greater during the breeding season than other seasons (Brivio et al., 2010). Moving is closely related to feeding also (Fig. 2). Other activities were observed mainly in the morning hours and late evening hours. This may be due to the absence of feeding and moving in that time.

The animal shows a diurnal activity pattern. In any of the night observations, spotted deer were not found to be active. The other types of activities were mostly found in morning and evening time periods. The drinking activity was mainly noted in the mid-noon periods. But in captive conditions, the prominent activity was resting (42.92%), the feeding activity was (22.89%), other activities were also found to be more (Nelda and Oktarina, 2021). This activity pattern is different from the activity patterns of spotted deer in Parambikulam Tiger Reserve these changes may be due to the climatical changes in the wild and the absence of predators in captivity.

A. axis spent less time for breeding and other type of activities (Table 3.1 and 3.3). As the predation pressure from tiger, leopard and wild dog were found to be more in Parambikulam Tiger Reserve, the spotted deer showed less activities such as breeding and other activities when compared to the activities of captive spotted deers. Mounting evidence indicates that fear of predation can affect the behaviour and demographic rates of prey (Brown and Kotler, 2004). Risk effects include reduced foraging efficiency and increased physiological stress (Lima and Dill ,1990, Creel, 2011). In the Parambikulam tiger reserve, the predation pressure seems to be higher, tigers, wild dogs and leopards are found in almost every habitat. Many times, the wild dogs were found attacking spotted deer. The activity patterns seem to be disturbed by wild dogs on many occasions. However, the overall activity pattern doesn't seem to be influenced by the presence of predators. The activity patterns are almost similar to many other studies on spotted deer in different regions.

When undisturbed, hog deer are mainly crepuscular some daytime activity (Dhungel and O'Gara, 1991), while in areas of high human population or high hunting pressure they may shift to nocturnal activity (Timmins et al., 2015). Feral and domestic animals (including dogs) as well as people were abundant throughout the study area. In Parambikulam Tiger Reserve no high hunting pressure or high human population, feral and domestic animals (including dogs) were not present. Many times, observation of spotted deer's activity at night are done. They were found to be resting in night periods, no activity other than resting noted.

In the natural forest ecosystems, the spotted deer faces more variations in food availability, water availability, solar radiations and predation pressure. In such a system significant variation in activity patterns will be expected. Among red deer in Europe, daily activities was generally affected by the dark and light cycles, with bimodal activity peaks which are coinciding with dawn and dusk (Jeppesen, 1987;

Carranza et al, 1991). Seasonal differences in activity may be due to changes in daylight hours, metabolism of deer and quality and quantity of forage (Georgii, 1981; Green and Bear, 1990). In Parambikulam Tiger Reserve significant seasonal variations in feeding, moving, resting and drinking activities were recorded (Table 1 & 2). Spotted deer spent most of the time is feeding, resting, moving, social activity, antipredator and other activities in the wild (Sharatchandra and Gadgil, 1980).
Spotted deer prefer resting in noon and feeding at morning and evening in wild (Fig. 2) contrary more active in feeding during noon and rested at morning in captivity (Rajawat and Chandra, 2020). The vigilance responses were found almost absent in the absence of predators in captivity (Davey, 2005). Artificial conditions such as anthropogenic interference, closed environment and non-existence of predators altered the natural behaviour of animals in captivity.

CONCLUSION

The activity pattern of A. axis differed with respect to sex and seasons. The animals in the group were classified into sex categories and the activities of the animals were classified as feeding, drinking, moving, resting, breeding and other activities. The animal showed a diurnal activity pattern where feeding constitutes the major component of all activities. However, A. axis spent less time for breeding and other type of activities.

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