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Diurnal Activity Patterns of Burchelli Zebra (*Equus burchelli*) in Captivity at Zoological Garden, Alipore, Kolkata, India

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ABSTRACT:
A study was conducted on the diurnal behavioural pattern and activity time budget of a captive female burchelli zebra (*Equus burchelli*) in the Zoological Garden, Alipore, West Bengal, India, from 10.00 to 17.00 h between October 2022 to June 2023including winter and summer seasons by using focal sampling method with 25,200 minutes of observations. Data were analyzed by assessing mean time spent percentage for different activities in different hours and different seasons. Differences in the seasonal and hourly time budget were tested using one-way ANOVA, followed by DMRT. Grazing was dominant with significantly ($P<0.05$; DMRT) maximum time spent, followed by standing, feeding of offered feed, resting and then locomotion during both the seasons. Between seasons, significantly higher ($P<0.05$; DMRT) grazing (32.72%±0.92), walking (7.58%±0.77) and sleeping (7.18%±0.24) behaviours were observed during summer, while the other activities during the winter. During summer, from 12:00-13:00 h, grazing was the lowest, while resting was most. During winter, resting was more in the 1st hour of observation. The zebra devoted 2.12% to 2.21% of their time towards vigilance behaviour which was with higher rate during winter. This individual-based behavioural study on captive zebra will be useful for taking a well comprehensive management plan to ensure its successful in-situ conservation as well as its welfare.

Keywords:
Activity Time Budget, Behavioural Pattern, Burchelli Zebra, Focal Sampling, Seasons.

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INTRODUCTION

Burchelli zebra (*Equus burchelli*), the odd-toed ungulate, belonging to family Equidae, having distinctive feature of vertical black and white stripes on the forepart of trunk and horizontal stripes on the hindpart. They are one of the most abundant and native species of Africa (Hack, East, & Rubenstein, 2002; De-Vos, Leslie, & Ransom, 2020). They are primarily grazer, feeds on mainly short young shoot and long flowering grasses (Owen-Smith, 2002; Moehlman, 2003). They historically occurred in nearly all the countries of eastern, southern and south-western Africa before the 1990s (Hack et al., 2002). At present they range from South Sudan and southern Ethiopia to southern Angola and northern Namibia and northern South Africa and formerly ranged from south of the Orange and Vaal Rivers to the Cape (Hack et al., 2002; Klingel, 2013). In the countries, such as Burundi and Lesotho, they were now extinct, but formerly present. Moreover, are likely to be extinct in Somalia (Hack et al., 2002; Klingel, 2013). The population of this species reduced about 24% since 2002 and in past thirty years this species has experienced nearly 25% decline of their natural populations and also significant range reductions (King & Moehlman, 2016). Thereby, this species is listed as near threatened as it is close to qualifying for vulnerable (King & Moehlman, 2016).

According to Shepard et al. (2008), animal behaviour is a "fundamental part of its biology". Behaviour could be explained as a response of an animal to the environment and also to its intrinsic stimuli such as craving, anxiety etc (Shepard et al., 2008). Animal behaviour could also be delineated as how the animal communicate with the surroundings, environment and with other animals and also with each other. Behavioural pattern of different species of animals markedly varied from each other with the habitat conditions (e.g., resource availability), environmental factors (climatic factors like temperature, rainfall etc.) and the social factors (Hazarika & Saikia, 2010). Behaviour study is the study on the natural behaviour of the animal, their coherent abilities and psychological condition (Jayne & Lee, 2019). Knowledge about wild animal's behaviour, is very much crucial for their in-situ as well as ex-situ conservation (Swaisgood & Greggor, 2019). Numerous studies have been conducted on wild population of plains zebra (Fischhoff, Sundaresan, Cordingley, & Rubenstein, 2007; Fischhoff, Dushoff, Sundaresan, Cordingley, & Rubenstein, 2009; Georgiadis, Hack, &Turpin, 2003; Klingel, 1969; Rubenstein, 1994, 2010; Rubenstein & Hack, 2004). Sufficient information and datawere documented onthe social organization, population ecology, feeding ecology, habitat use and reproductive status of the burchelli zebra by numerous authors (Fischhoff, 2009; Fischhoff et al., 2007; Gasaway, Gasaway, &Berry, 1996;Goargiadis et al., 2003; Klingel, 1969; Rubenstein, 1994, 2010; Rubenstein & Hack, 2004). A few studies were carried out on captive plains zebra (Andersen, 1992; Ford & Stroud, 1993; Pluhacek, Bartoš, & Čulík, 2006). No data is available on the individual-based activity pattern and energy budget of zebra in captivity. Nowadays, behaviour study of wild animals in zoo is a widely accepted research area as it provides an evidence-based approach for improving the management strategies of zoos. For ex-situ conservation, zoo is the best possible house for the wild animals as it establishes their natural habitat inside the enclosure (Shepherdson, 1992). The main purpose of zoo is to increase reproductive success of wild animals and to enhance public awareness, and importantly to assure wild animal's welfare (Young, 2003; Barongi, Fisken, Parker, & Gusset, 2015).

The activity time budget of an animal, states that the animal performed different activities in a specified time period (Baskaran, 2013). Behavioural profile of an animal depends on its diurnal and nocturnal activity time budget as different animal distribute its time and energy budget individually in order to maximize its fitness (Adolfsson, 2009).Understanding individual activity budget of captive animal could be useful to establish the behavioural profile of that captive animal, to illustrate the animal's state of well-being and to indicate any alteration of their natural behaviour and identifying the abnormal or stereotypic behaviour, if observed (Bracke & Hopster, 2006).

Stereotypical behaviour is a set of uniform behaviours performed by the animals repetitively, that have no functional value to the animals (Mason, 1991).

By nature, zebra is a diurnal species (Regassa & Yirga, 2014). As burchelli zebra, an endemic species of Africa, in India it is only found in zoos, their activity budget might be altered due to change in environmental factors (temperature, humidity, rainfall etc.) as well as their habitat. Hence, study on the activity budget of captive zebra in India, offers detailed information about the animal's basic needs and necessities, cognition and preferences which would be a beneficial for their well-being, health and management and also for accessing the abnormal, stereotypic or stress behaviours by comparing the behaviours of captive zebra with their wild conspecific. Therefore, the amount of stereotypic behaviour obtained from the activity time budget of the studied captive animal, might be considered as an indicator of their poor welfare (Mason & Veasey, 2010). Wild animals are kept in a very small enclosure of zoo, compared to free ranging wild animals and thereby, they become stressed (Anderson,Arun, & Jensen,2010) and displayed abnormal behaviours (Rees, 2011). Limited space of the enclosure and restricted environment were the main cause of their reduced natural behaviours (Swaisgood & Shepherdson, 2005). Some other causes behind the stereotypic behaviours are husbandry procedure, rearing history and genetic factors (Liu et al., 2003).

Activity pattern of an animal could be influenced by many factors such as temperature, climate, biological cycles, light and darkness, phases of moon, etc. (Kamler, Jedrzejewska, & Jedrzejewska, 2007). According to Krebs and Davies (1997), features of the environment shape the animal's behaviour. Hence, changes in environmental factors should be responsible for the change in the behaviour pattern. Regassa and Yirga (2014) reported that diurnal activity patten of wild zebra could be varied depending on seasons.

Hence, the present study was conducted on a female burchelli zebra (*Equus burchelli*), kept in Zoological Garden, Alipore, Kolkata over a period of approximately nine months to assess its behaviour pattern in terms of detailed diurnal activity time budget and also to determine the seasonal impact on its activities.

MATERIALS AND METHODS

Study area:

The present study was conducted at India's oldest zoo, the Zoological Garden (22◦32'9.29'' N, 88◦19'55.39" E), Alipore, Kolkata, West Bengal, India. The zoo was established around 1800 by Governor General of India, Richard Wellesley. This zoo was inaugurated on 1st January 1876. It covers area of about 18.811 ha (46.48 acres). Soil structure of the Zoo is loamy alluvial. The climatic condition is moderate. Summer season starts in the month of March and ends with the onset of monsoon in June. During summer season, maximum temperature rises up to 40^{O}C with an average of 36^{O}C. Winter season begins in the month of December and ends in the months of February. The lowest temperature of the winter season is near 10^{O}C with an average of 13^{O}C. Here, monsoon starts in the 1st week of June and ends in the month of September. The yearly rainfall of Kolkata is about 1836.5 mm. (Figure 1)

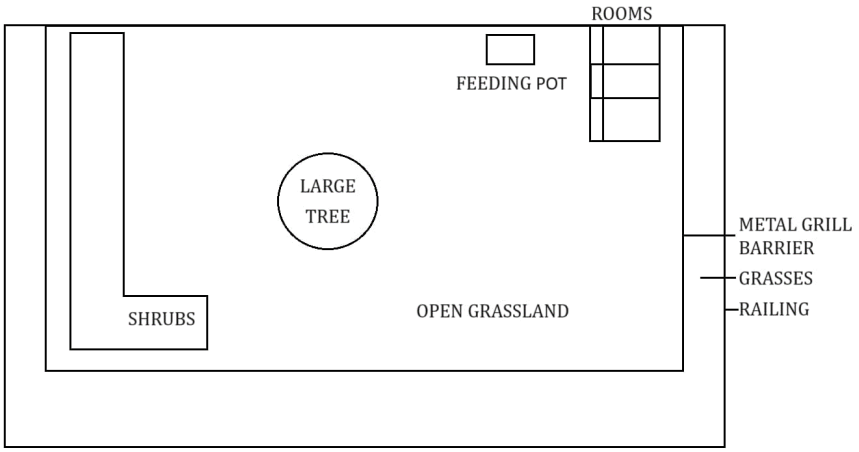

Figure 1: Layout of *E. burchelli* enclosure at Zoological Garden, Alipore (based on visual observations during present study).

Study animal:
The studied animal is a female burchelli zebra (*E. burchelli*), kept along with another four females, three males and one female calf in an enclosure. Four zebras were brought to the Alipore zoo from Israel by Directorate of Forests Government of West Bengal in 2011. Currently, there are nine zebras in zoo and the number is increased by captive breeding. The food is provided by the Alipore zoo authority to the zebras. Their diet basically includes concentrated feed, sweet potato, carrot, soaked gram, soaked maize, crushed maize, vegetables, hey grasses etc. The food is provided to them twice in a day (08:00 h and 16:00 h) inside the zebra enclosure. Rest of the time they graze for grasses, leaves, etc.

Enclosure of the Animal:
The studied animal was kept in an enclosure situated in the eastern part of the zoo. The enclosure is about 2000 sq.m. This open-air enclosure is bounded by metal grill barrier. The ground of the entire enclosure has covered with grasses, shrubs and inside the enclosure there is one big sized Brazilian Ironwood tree, *Libidibia ferrea*. The enclosure had three shelters and one feeding pot at the east side of it.

Ethogram:
An ethogram is a list of behaviours performed by an animal or it could be described as a complete catalogue of the behavioural patterns of the studied animal. The activities performed by an animal, are the naturally occurring continuous flow from one event or state to another. This flow of activities performed by that animal, is broken down and categorized into a list, in which a particular behaviour is distinct and could be measured in terms of time budget. In ethogram, each of the behaviour is denoted by a suitable name with proper description. On the basis of previous behavioural studies on zebra (Regassa & Yirga, 2014; Kabir 2022; De-Vos et al., 2020) and preliminary observations, an ethogram was prepared for this study on zebra (Table 1). A total of 15 activities were identified for the zebra in Alipore Zoological Garden. These activities were feeding, grazing, standing, walking, running, playing, lying down, sleeping, grooming, social, dust bathing, tails swing, vigilance, urination and defecation.

Table 1: Ethogram used for collecting behavioural data of *burchelli zebra* in captivity at Alipore Zoo, Kolkata (based Vos et al., 2020).

Name of behaviours	Description
Feeding of offered feed	consumption of food mixtures provided by zoo
Grazing	eating the grasses from the enclosure field
Standing	standing with four feet and with no forward and backword movement
Walking	movement in various sites at a normal walking pace except while grazing.
Running	moving fast in one particular direction
Playing	playing with another zebra
Lying down	lies on ground downing its head with apparently opened eyes
Sleeping	lies downing its head with apparently closed eyes and no alertness.
Grooming	scrubbing the body cover on tree bark and licking itself for cleaning its body.
Social	appealing for associative contact with the other individual
Dust bathing	dust bathing to remove unwanted organisms mainly insects and eco-parasites and other things from skin.
Tail Swing	wagging its tail around the body
Vigilance	standing with rigid body posture, head up, ear forward and eye open and alertness to its surroundings
Urination	discharging urine
Defecation	discharging faecal matter

Data collection:

For the study on diurnal activity pattern of female *burchelli zebra* at the Alipore zoo, data were collected from 1st October, 2022 to 30th June, 2023(9 months study, 5 months from winter and 4 months from summer). Data were recorded during day time from 10:00 to 17:00 h, twice in a week, through direct observation with unaided eye by using focal sampling methods and marked on sheet. All the activities were recorded in each minute with a gap of 1 minute in every five minutes from a suitable point without creating any disturbances to animal. Total observations were carried out for 25,200 minutes, 14,000 minutes from winter season and 11,200 minutes from summer season.

Data Analysis:

The observations were categorized into different activities. For each activity duration was recorded. To determine activity time budget, the displayed activities by the studies zebra were presented as mean percentage of observation period, spent in performing each activity. All the graphical representations were prepared by using MS-Excel software. 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 performed for multiple comparisons at the significance level of 0.05 to compare the differences in activity patterns for hourly and seasonal data.

RESULTS

A total of 25,200 minutes of diurnal behavioural data of *E. burchelli* were collected for the present behaviour study. Analysed data were presented as percentage of time spent by the burchelli zebra.

Diurnal activity budget of burchelli zebra during winter season (Fig.2)

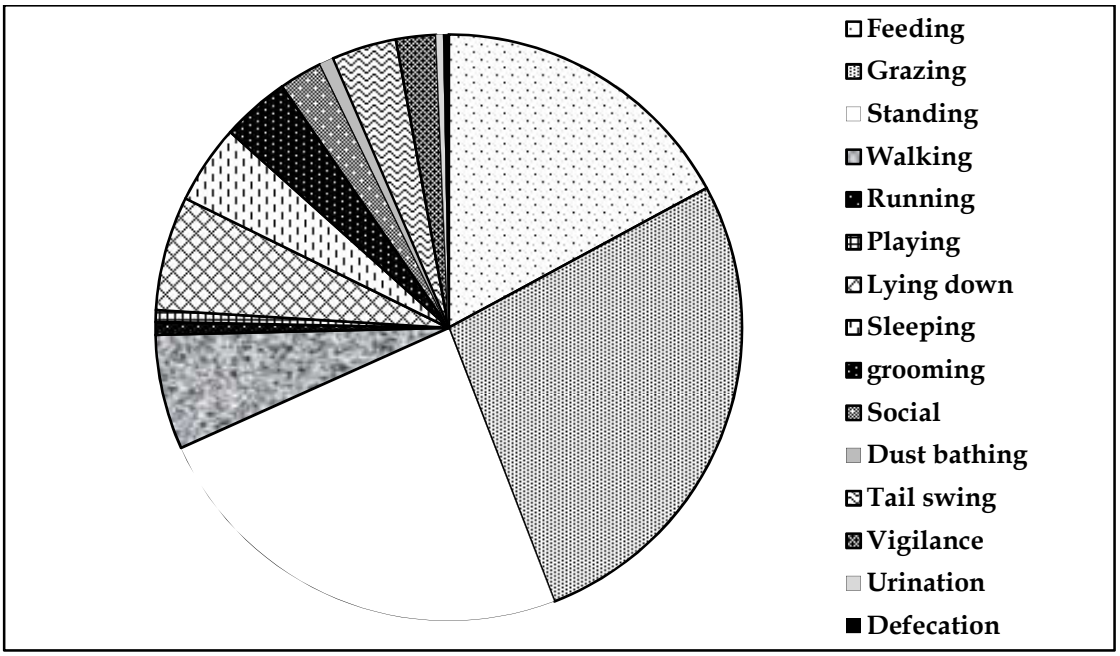

Figure 2: Percentage of time spent in different behavioural categories by *E. burchelli* during winter season at Alipore Zoo.

During the winter season, the studied *burchelli zebra* spent 44.14% time of total observation period, in performing the feeding activities, in which 17.10% in feeding of offered feed and 27.03% in grazing activity. The zebra allotted 7.03% time in locomotion activity, which had 6.33% for walking and 0.7% for running activities. The mean time spent percentage accounting for the resting behaviour was found 10.66%. Within the allotted time for resting, lying down was noticed for 6.30% and sleeping for 4.35%.

The zebra devoted significantly highest amount of time for the grazing activity, followed by standing (24.15%) and then feeding of offered feed (17.10%). Almost equal amount of time was spent for walking and lying down activities, where mean percentage of time spent for these activities did not show significant variation in DMRT ($P<0.05$). Significantly the lowest ($P<0.05$; DMRT) amount of time spent by the zebra in defecation activity (0.30%). For the grooming, tail swing, social, vigilance, dust bathing, playing and urination activities, the zebra spent 3.76%, 3.58%, 2.39%, 2.20%, 0.76%, 0.65% and 0.38% time respectively.

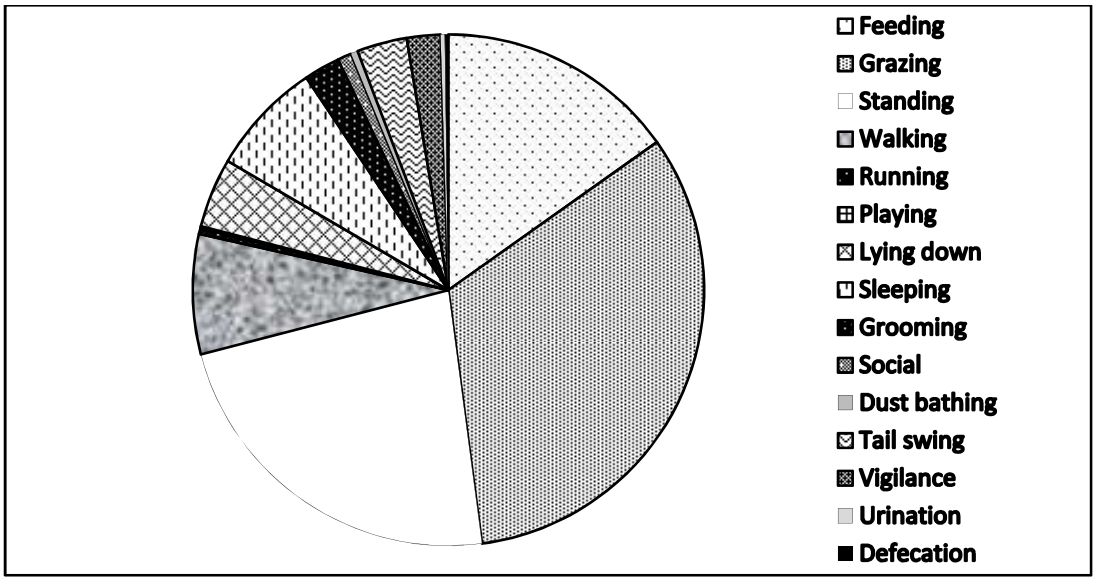

Figure 3: Percentage of time spent in different behavioural categories by *E. burchelli* during summer season at Alipore Zoo.

Diurnal activity budget of burchelli zebra during summer season (Fig.3)

During the summer season, the mean time spent for the feeding activities by the studied zebra was noted 47.90% time of total observation period. Within the feeding activities, the zebra allotted 15.18% time for the feeding of offered feed and 32.72% time for grazing activity. For the locomotion activities, time spent by the zebra was found 7.96%, allocating 7.58% for walking and 0.38% for running. The zebra allotted 11.59% time in resting activities in which for lying down was 4.40% and for sleeping was 7.18%.

During the summer season, the studied *burchelli zebra* was found to be spending maximum (P<0.05; DMRT) time in the grazing activity, followed by the standing (23.06%) and feeding (15.18%) activities. The mean percentage of time spent by the zebra performing tail swing, grooming, vigilance, social, dust bathing, urination, defecation and playing activities were 3.15%, 2.28%, 2.12%, 0.87%, 0.46%, 0.28%, 0.22% and 0.12% respectively.

Comparison of diurnal activity budget of the of burchelli zebra between seasons (Fig.3)

When data of mean time spent percentages were compared between the winter and summer seasons, it was observed that total time spent for the feeding, locomotion and resting activities were maximum during summer season. When feeding activities were considered, it was found that the time spent for feeding of offered feed significantly higher (P<0.05, DMRT) during winter season, whereas an inverse result was obtained for grazing activity which was maximum (P<0.05, DMRT) during the summer season. Under locomotion activities, running was maximum during winter and walking during summer, and under resting activities, lying down was maximum during winter and sleeping during summer. The time dedicated for the playing, grooming, social and dust bathing activities were found to occur at significantly higher frequencies during the winter season compared to the summer season. While the time spent for tail swing, vigilance, urination and defecation activities between the two studied seasons did not show significant variation in DMRT (P<0.05). (Figure 4)

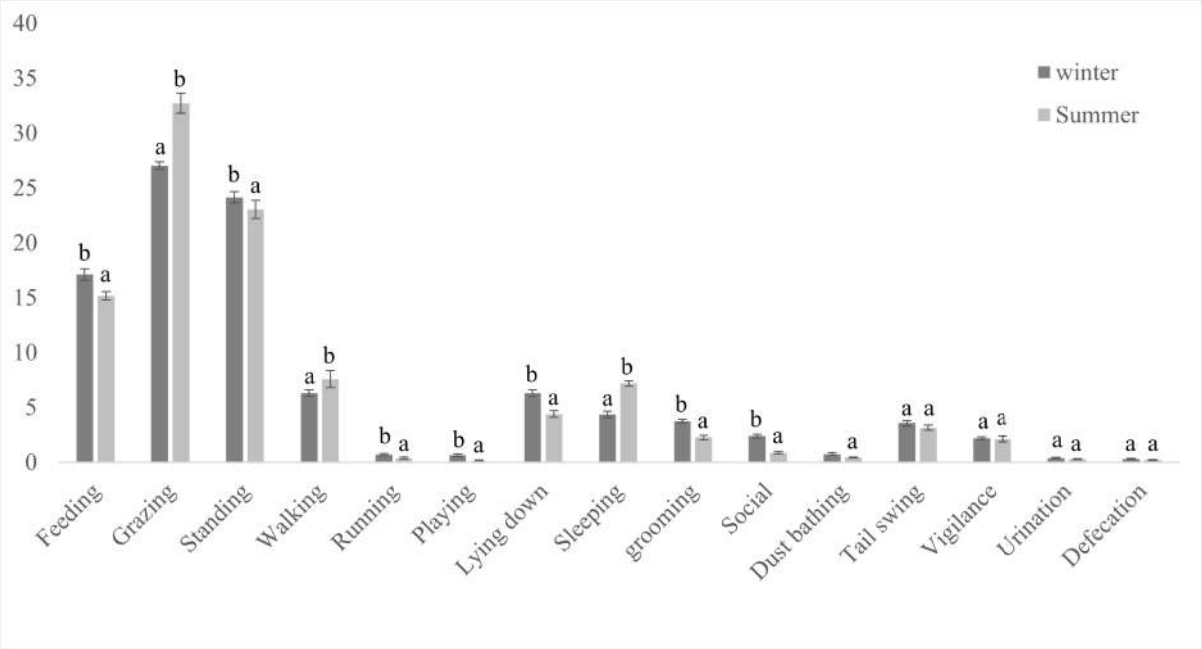

Figure 4: Percentage of time spent in different activities by *E. burchelli* in three different seasons at Alipore Zoo. Values are mean ± SE. Bars with different letters are significantly different (P<0.05) using DMRT after one way ANOVA.

Table 2: Mean percentage of hourly activity budget of different behaviours displayed by *E. burchelli* from 10.00 h to 17.00 h during winter and summer seasons at Alipore Zoo, Kolkata.

Activities	10:00-11:00		11:0-12:00		12:00-13:00		13:00-14:00		14:00-15:00		15:00-16:00		16:00-17:00	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Feeding	16.81	14.28	18.12	21.45	10.51	11.59	15.36	15.58	19.57	16.99	16.09	18.25	23.26	18.11
Grazing	23.62	12.79	27.32	12.97	25.43	9.11	24.57	14.46	32.32	14.44	21.23	16.62	34.71	11.45
Standing	22.75	43.14	26.16	34.34	26.59	46.20	25.72	21.91	20.87	30.67	25.14	32.49	21.81	42.82
Walking	7.61	7.60	5.80	8.55	7.83	7.67	4.93	5.81	5.14	11.17	7.90	8.64	5.07	8.90
Running	0.43	0.00	1.38	0.62	0.80	0.45	0.22	0.26	0.58	0.63	0.29	0.32	1.23	0.61
Playing	0.43	0.00	0.43	0.00	0.29	0.00	1.45	19.01	0.43	0.00	0.72	0.00	0.80	0.00
Lying down	7.97	5.59	4.57	3.11	7.90	5.12	6.74	3.96	2.97	6.92	11.52	6.08	2.46	3.07
Sleeping	8.48	6.98	2.03	9.79	5.94	12.64	7.46	6.34	2.83	7.39	2.03	4.80	1.74	6.91
Grooming	3.99	2.79	3.62	1.55	3.55	1.96	3.33	3.70	4.93	2.20	4.64	3.04	2.25	2.00
Social	1.96	1.55	3.12	0.00	2.03	0.00	2.46	1.19	3.70	0.79	1.81	1.60	1.67	1.53
Dust bathing	0.58	0.47	0.58	0.93	1.38	0.30	0.51	0.53	0.36	0.94	1.52	0.32	0.36	0.00
Tail swing	3.62	2.79	3.70	3.11	3.91	3.16	4.28	3.43	4.06	4.72	3.91	4.32	1.59	2.61
Vigilance	1.09	1.55	2.39	2.95	3.19	1.35	2.61	3.04	1.67	3.15	2.46	2.40	2.03	1.69
Urination	0.58	0.47	0.58	0.31	0.22	0.30	0.22	0.53	0.36	0.00	0.58	0.32	0.14	0.15
Defecation	0.07	0.00	0.22	0.31	0.43	0.15	0.14	0.26	0.22	0.00	0.14	0.80	0.87	0.15

Hourly activity time budget of the burchelli zebra (Table 2)

During winter season, under the feeding activities, both the feeding of offered feed and grazing activities were reached peak at 16:00-17:00 h. Under locomotion behaviour, walking activity was noted to occur with a higher frequency at 15:00-16:00 h, while the running activity at 11:00-12:00 h. When resting behaviour was considered, sleeping activity reached the peak at the 1st hour of the observation period, whereas lying down at 15:00-16:00 h. Among the other remaining activities displayed by the zebra, standing activity reached the peak at 12:00-13:00 h, playing and tail swing at 13:00-14:00 h, grooming and social activities at 14:00-15:00 h, dust bathing at 15:00-16:00 h, defecation at 16:00-17:00 h. Urination frequency was found maximum at 10:00-12:00 h and 15:00-16:00 h.

During summer season, under the feeding activities, feeding of offered feed and grazing activity reached the peak at 11:00-12:00 h and 15:00-16:00 h respectively. Under locomotion behaviour, the peak hour for both the walking and running activities was14:00-15:00 h. Under resting activity, sleeping and lying down activities occur at higher rate at 10:00-11:00 h and 14:00-15:00 h respectively. Among the other remaining activities, standing activity found to occur with maximum frequency at 12:00-13:00 h, playing, grooming and urination at 13:00-14:00 h, dust bathing, tail swing and vigilance at 14:00-15:00 h and defecation at 15:00-16:00 h.

From 10:00 to 11:00 h (Table 2):

When mean time spent percentage of the studied zebra was compared within season, it was found that during winter season, time spent for the grazing activity (23.62%) was the maximum, followed by the standing, feeding, sleeping, lying down and walking activities. During summer season, among all the activities displayed by the zebra, walking activity was observed to occur at significantly higher frequency, followed by feeding of offered feed and then grazing activity. In the 1st hour of the observation period, no running, playing and defecation activities were observed. When data were compared within the activity and between the two studied seasons, it was noted that except standing, vigilance and walking activities, all the other behaviours performed by the zebra, occurred at higher frequency during the winter season, whereas standing and vigilance activities occurred at maximum rate during the summer season and the time spent for walking activity during the winter and summer seasons, were found to be almost equal.

From 11:00 to 12:00 h (Table 2):

When data were compared within season, the zebra showed a similar trend of results in the time spent percentage during the winter and summer season as observed in 1st hour of the observation period. When data were compared between the studied seasons, the zebra allotted maximum time for grazing, running, playing, lying down, grooming, social, tail swing and urination activities during the winter season, whereas for feeding, standing, walking, sleeping, dust bathing, vigilance and defecation activities during the summer season.

From 12:00 to 13:00 h (Table 2):

When data were compared within season, the zebra was found to be spending maximum time in standing activity during both the seasons. Between the winter and summer seasons, except feeding, standing, sleeping and urination activities, all the other activities were found to occur at higher rate during the winter season.

From 13:00 to 14:00 h (Table 2):

When mean time spent percentages were compared within season between activities, during both the winter and summer seasons, a similar type of results was found as observed in 12:00-13:00 h for the activity occur at maximum rate and the following two activities. Between seasons, grazing, standing, lying down sleeping, social and tail swing activities were found to occur at higher rate during the winter season, whereas feeding, walking, running, playing, grooming, dust bathing, vigilance, urination and defecation during the summer season.

From 14:00 to 15:00 h (Table 2):

Within season, the maximum and the following two high frequency behaviours were unvaried as observed in the 1st two hours of the observation periods. Time spent for feeding of

offered feed, grazing, playing, grooming, social, urination and defecation activities by the studied zebra, were maximum during the winter season, while the allotted time for standing, locomotion, resting, dust bathing, tail swing and vigilance were maximum during the summer season.

From 15:00 to 16:00 h (Table 2):
Within the studied season, the behaviours with maximum time spent and the following two, were found similar as observed at 12:00-14:00 h. Between seasons, the time dedicated for grazing, playing, lying down, grooming, social, dust bathing, vigilance and urination activities were found to occur at higher rate during the winter season, whereas the time spent for the remaining other activities displayed by the zebra, were maximum during the summer season.

From 16:00 to 17:00 h (Table 2):
When data of mean time spent by the studied zebra were considered, it was noticed that within season the trend of results for the maximum time spent and the following two behaviours were same as observed during the 1st two hour of observation period. When data were compared between the winter and the summer seasons, it was noted that the maximum time spent for feeding, running, playing, grooming, social, dust bathing, vigilance and defecation were found during the winter season, whereas other activities during the summer season.

Cluster Analysis:
Cluster analysis along with heat map depicted the relationship between the behaviours along with the frequencies. In the winter season it was observed that grazing was the most dominant behaviour and its frequency was highest amongst the behaviours displayed by the zebra (Fig.5). Second most predominant behaviour was the standing, followed by the feeding of the offered feed activity. Running, playing, dust bathing, urination and defecation activities were highly correlated together and occurred almost in the same frequency and hence was clustered together. It was also found that tail swing, grooming and sleeping activities were clustered along with lying down and walking activities. This explained that during the winter seasons, except the feeding, standing and grazing, all the activities performed by the studied zebra, were highly correlated and occurred nearly in the similar frequency.

Figure 5: Cluster analysis with heat map of active behaviour of *E. burchelli* in winter season

A similar image was also observed during the summer season with a little variation in the frequencies of the behaviours (Fig. 6). During the summer season, according to frequency of occurrence, the most predominant behaviour was grazing, followed by standing and then feeding. Running, dust bathing, urination, defecation, playing and social activities were highly correlated to each other and occurred almost in the same frequency and hence is clustered together. Similarly, vigilance, grooming, tail swing and lying down activities were clustered along with sleeping and walking activities. This stated that during the summer seasons, except the feeding, standing and grazing, all the other activities were highly correlated and occurred nearly with the similar frequency.

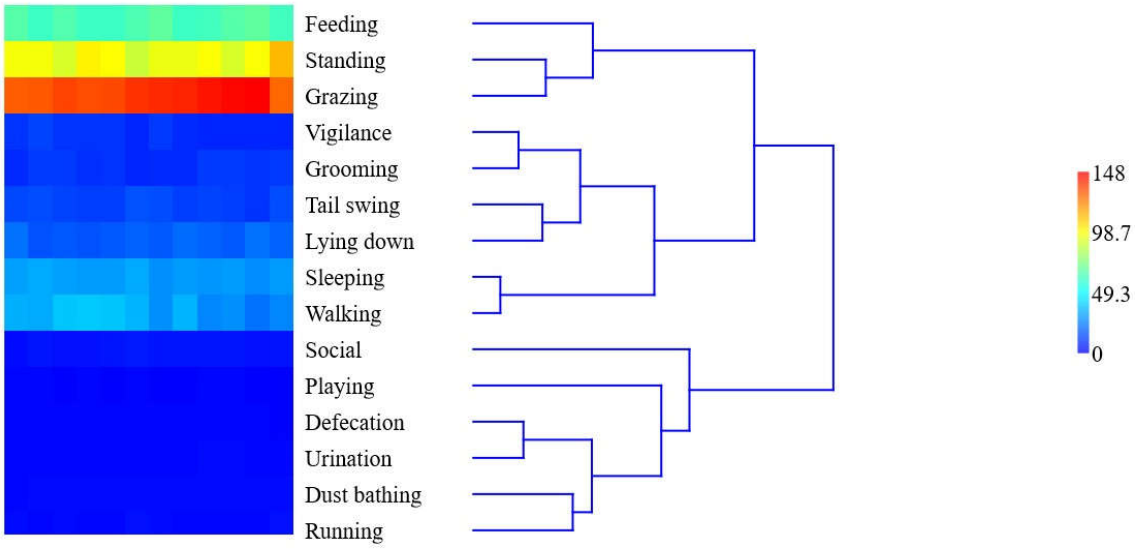

Figure 6: Cluster analysis with heat map of active behaviour of *E. burchelli* in summer season

PCA:

Principal Component Analysis revealed that two components showed an eigenvalue of >1. The analysis was done in variance-covariance matrix. The image presented in figure 7 showed that in the winter season the major variance was shown by the feeding and standing behaviours. Between them standing behaviour scoring the maximum. Whereas, grazing and walking behaviours showed the maximum variation during the summer season. All the other behaviours were not season specific and showed the same frequency in both the seasons.

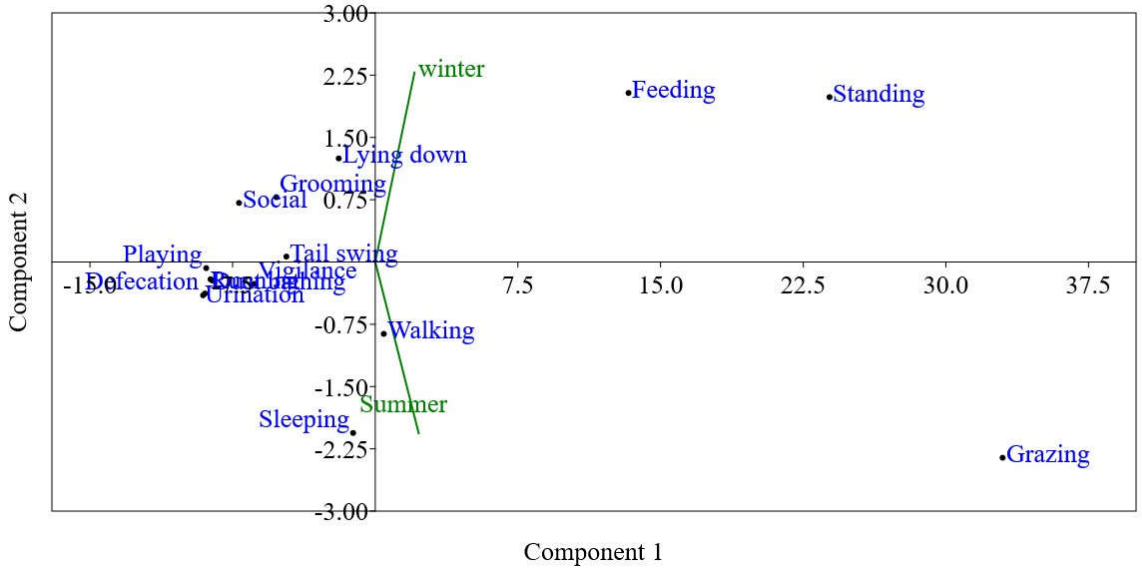

Figure 7: PCA Biplot showing the variance of behaviours in the seasons under study.

DISCUSSION

Behaviour is any action displayed by an animal, could be the response to an internal or external stimulus, or how the animal interacts with each other, with the other organisms and the physical environment. It could also be defined as "behaviour is a product of the features of its environment" (Krebs & Davies, 1997). Though the behavioural pattern and activity budget of an animal is species specific, remarkable variations exist among the individuals or groups, belonging to a same species. Individual-specific behavioural patterns are the results of variations in their responses which are the outcome of varied habitat conditions, environmental factors, the social factors (Hazarika & Saikia, 2010) and internal biological factors (Knoop & Owen-Smith, 2006). Hence, behavioural pattern and activity budget of an animal influenced by numerous factors which might be the biotic environmental factors, biological cycles, body mass of the studied animal, human disturbance, predators, feeding bouts, food acquisition and competition for resources and shelters (Regassa & Yirga, 2014). Within abiotic environmental factors, climate, light and darkness, phases of the moon, temperature, humidity and rainfall had an impact on daily and seasonal activity patterns of the animal (Kamler et al., 2007).Earlier studies on ungulates depicted that foraging efficiency was determined by the time of day, temperature, seasons and vegetation type. (Shi, Dunbar, Buckland, & Miller, 2003; Wobeser, 2006; Neuhaus & Ruckstuhl, 2002). In this regard Robert and Dunbar (1991) also reported that the seasonal variations in the daily activity of wild reedbuck correlated with the environmental factors (temperature, rainfall etc.) and ground plant biomass.

The results revealed that the activity time budget of the burchelli zebra had a distinct pattern which was noted both in the winter and summer seasons, though between the seasons, variations were found in the amount of time spent for the activities performed by the zebra. During both the seasons it was noted that the zebra allotted more time for the grazing activity than all the other activities. During summer season, grazing was the lowest from 12:00-13:00 h. A similar finding was obtained by Regassa and Yirga (2014) and stated that at midday, zebra showed the less grazing activity. According to their study, this might be due to higher ambient temperature that altered the green leave's turbidity which had an impact on

plants' palatability. Under feeding activity, it was observed that during dry winter season, grazing was minimum and feeding of offered feed was maximum. The possible reason might be less availability of green nutritious grasses during winter, hence the zebra relied on offered feed. Whereas, during humid summer season, the floor of enclosure almost covered with grasses, so the zebra performed more grazing and consumed relatively less amount of offered feed compared to the winter season. The inverse scenario was noticed in case of wild free ranging zebras. Grazing activity was more during the dry season and less during the summer season. During dry winter season due to less availability of food, they grazed more to fulfil their nutritional requirement (Regassa & Yirga, 2014). Distribution of time budgets in grazing activity by captive zebra and wild zebra varied between seasons which led to infer that ambient temperature, rainfall and food availability might be the determinant factors controlling the seasonal activity pattern of the Burchelli zebra (Regassa & Yirga, 2014). Moreover, it could be asserted that seasons act as a significant predictor for the feeding activity time budgeting by the zebra.

Seasons had an effect on the resting behaviour of the zebra in Alipore zoo, with more time spent to resting during the summer season than the winter. This finding was in the line to the earlier observation on equids (Keiper,Moss, & Zervanos, 1980). Whereas De-Vos et al. (2020) reported the zebra in Majete allocated more time to resting during the winter season than the summer. King, Asa, Plucháček, Houpt, and Ransom (2016) explained that the limited food resource during winter might be the possible cause of decrease in resting in the amount of time spent to feeding. While in the current study, the time allocated to both the resting and feeding was found less during the winter season might be due to differences in study design or due to not incorporation of nocturnal activity data.

In the present study, it was observed that the zebra rested most between 12:00-13:00 h during the summer seasons, whereas resting was less during the 1st and last two hours of the observation period. Resting reached the peak during the midday in summer due to high scorching ambient temperature. While during winter season, resting was more in the 1st hour of the observation period. This might be due to low temperature of morning time, when the zebra displayed more resting under the sun to keep itself warmer. Hence, it could be stated that resting activity of captive zebra was also affected by the ambient temperature. The similar finding was noticed in free ranging zebra of Yabello wildlife sanctuary, Southern Ethiopia (Regassa & Yirga, 2014). These zebras spent about 25% to 35% of their diurnal time in standing and resting under the shade of Acacia woodland to escape from the intense heat of midday. In the current study a similar result with about 35%of day time engaged in standing and resting activity by the zebra was noted. Between 12:00-13:00 h, the total spent time for the resting and standing was high, which was about 64% and 40% of the total resting and standing period during summer and winter season respectively. When considering the standing activity, the trend of result was consistent with the total of standing and resting activities. This is in line with the findings of Sandra (2009) in which Burchelli zebra spent most time in standing during the midday period. Hence, the studied zebra displayed more resting and standing during the middle of the day, whereas maximum grazing was noted in the afternoon. In the several prior studies (Gakahu, 1984; Beekman & Prins 1989; Sandra, 2009; Regassa & Yirga, 2014) a similar type of findings was reported with an additional peak of grazing during the morning. In the present study, increased grazing activity only documented in the afternoon, might had a peak in the early morning before the starting of the observation period.

In wild, mammalian free ranging herbivores spent their maximum time in feeding activity (Beekman & Prins, 1989). Grazing Equidae devoted up to 75% time of24-hour for the grazing (Crowell-Davis, Houpt, & Carneval, 1985; Houpt, O'connell, Houpt, & Carbonaro, 1986; Pratt, Putman, Ekins & Edwards, 1986; Fowler & Miller, 2003). Plains zebra in Majete devoted 41.8% of their daylight time budget in feeding behaviour (De-Vos et al., 2020). In this context, Neuhaus & Ruckstuhl (2002) indicated

that burchelli zebra in Ethosha National Park, Namibia, spent 54.3% time in grazing. Earlier five reports on wild plain zebra stated that they spend around 60% to 70% of 24-hour to the grazing activity (Gakahu, 1984; Beekman & Prins, 1989; Rubenstein, 1994; Simpson et al., 2012), whereas one report on wild Burchelli zebra, mentioned that grazing was about 55.5% of a day (Regassa & Yirga, 2014). A similar mean time spent percentage of grazing activity were reported for the Grevy's zebras of northern Kenya (Kivai, 2006) and of Lewa Wildlife Conservancy (Rubeinstein, Kirathe, & Oguge, 2004). Earlier studies on zebra and equids revealed that in order to meet their nutritional requirement, they need to allot 60% of their time in grazing under optimal condition, whereas under poor condition (resource availability) they allotted about 80% time. But an inverse trend was noted in case of zebra in Mejeta where in wet season, when high quality food is abundant, the zebra grazed for about 51% to 67% of their time, in contrast to 23% to 36% of their time during dry season as availability of resources were seasonally limited in Mejete (Rubenstein, 2010). Hence, it could be stated that resource abundance had a role to shape the feeding behaviour of zebra and seasonal variation in the feeding behaviour of zebra was a vital factor in their time budgeting. In the current study diurnal grazing activity was noted about 27% to 33%, which was found relatively lower than the earlier reports on wild zebra. It could be explained by the facts that the night activity budget of the zebra was not incorporated in the present study and the nutritious foods were provided to the captive zebra which lowered the urge of grazing due to fulfilment of their nutritional need.

Wild zebra allocated a largest proportion of their time (26.9%) for vigilance (De-Vos et al., 2020). The time devoted for vigilance was relatively comparable to the time spent for grazing activity. In the present study, the captive zebra devoted only 2.12% to 2.21% of their time towards vigilance behaviour. It was noticed that the zebra of the current study spent less time in vigilance behaviour in comparison to wild zebras of earlier reports. One of the possible causes for allotting more time in vigilance behaviour by the wild free ranging zebra, is to reduce the predation risk (Rubenstein, 2010). Wild zebra spent significantly more amount of time for vigilance during the dry season as risk of detected by the predator was more in dry season when the amount of ground vegetation cover was limited (De-Vos et al., 2020; Thaker, Vanak, Owen, Ogden, & Slotow, 2010). In the present study, the frequency of vigilance behaviour was also found higher during winter than summer, might be due to more visitor pressure during the winter season in the Alipore zoo. Wild zebras were found to be more vigilant in the morning and afternoon, less during midday (De-Vos et al., 2020; Simpson et al., 2012). Similar result was noted in hour budget of summer season of the captive zebra of present study. This could be explained by the fact that at midday, the predators are generally inactive and predation risk is less (Hayward & Slotow, 2009). While during winter season, the captive zebra showed maximum vigilance behaviour from 11:00 h to 14:00 h which was consistent with the standing activity that was also found more in the mentioned period. From 11:00 h to 14:00 h, during winter season, maximum visitor crowd was observed, might be the cause of more vigilant at that period.

Previous studied stated regarding the locomotion behaviour of zebras and other equids that amount of time allotted for moving was associated with the food resources over seasons (Brooke & Harris, 2008; Hampson, de-Laat, Mills, & Pollitt, 2010; King et al., 2016). Similar observation was obtained from the present study where locomotion was found more during summer season when the zebra spent more time in grazing also. No stereotypic behaviour was observed during the study period, which depicted that the zebra was healthy and not in stressed condition.

CONCLUSION

The findings from the present study revealed that the environment (especially the temperature) was the key determinant influencing the time budgets of the captive zebra of Alipore zoo. During both the season, grazing was found a predominant activity with significantly ($P<0.05$; DMRT) higher time spent by the zebra, followed by standing, feeding of

offered feed, resting and then locomotion. Between the winter and summer seasons, significantly higher ($P<0.05$; DMRT) grazing (32.72%±0.92), walking (7.58%±0.77) and sleeping (7.18%±0.24) behaviours were found during summer, while all the other activities were significantly maximum during the winter season. During summer season, from 12:00-13:00 h, grazing activity was found the lowest, while resting was maximum due to high scorching ambient midday temperature. During winter season, resting was more in the 1st hour of the observation period, due to low temperature zebra displayed more resting under the sun to keep itself warmer. The captive zebra devoted only 2.12% to 2.21% of their time towards vigilance behaviour which was with higher rate during winter due to visitor pressure.

This behavioural study on captive burchelli zebra will provide important insight towards the need of feeding enrichment incorporation for them, so that their natural grazing activity could be encouraged. The outcome of the present study will assist the zoo authority in identifying and mitigating the issues regarding in-situ conservation and ensure their welfare and will consequently lead to better future in-situ conservation by adopting improved management strategies for the captive zebra.

Moreover, this study will provide sufficient baseline data for understanding the captive zebras' time budgeting and, their behavioural pattern at zoo and also the impact of season on their activity time budget. This study will be helpful for conducting the future in-depth analysis of the activity budget and behavioural pattern of captive zebra.

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