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BEHAVIOURAL PATTERNS OF THE NORTHERN PIG-TAILED MACAQUE (*MACACA LEONINA*) AT THE CHITTAGONG ZOO OF BANGLADESH

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ABSTRACT: A total of five captive northern pig-tailed macaques (*Macaca leonina*) were observed from October 2022 to May 2023 using a structured ethogram to understand their behavioural patterns at Chittagong Zoo, Bangladesh. We detected nine activity patterns along with some abnormal behaviours using scan sampling methods with 5-minutes intervals. Diurnal and seasonal fluctuations in the behaviours were explicitly noticed. Locomotion was the highest (46.11%) time-consuming behaviour, followed by resting and grooming while bathing was the activity on which the macaques spent the lowest time (0.60%). *M. leonina* was mostly (29.44%) active during 09:00-11:00 h and engaged in less (18.41%) activity in the afternoon (03:00-05:00 h), which may be due to the captive environment. Seasonal patterns showed increased activity (25.59%) in late autumn and decreased activity (24.26%) in summer. These activities did not differ significantly within the pre-determined period (t = 1.95; P > 0.05). The macaques were found to be depressed for more time (24.36%) compared to other atypical activities such as debris eating, stereotypic pacing, begging, cage bar biting, etc. Time spent on these behaviors varied significantly during the study period (t = 3.62, P < 0.05). The unusual group structure, lack of captivity enrichment, and presence of the visitors – were assumed as the influences behind these abnormalities. Finally, we compared behavioural activities of captive *M. leonina* with activity patterns of wild groups published in the literature.

Key words: Activity budget, abnormal behaviour, captivity, enclosure, *Macaca leonina*.

INTRODUCTION

Behaviour is the display of phenotypic traits in an environmental setting that is molded by primary selective forces to achieve maximal and inclusive fitness (Eisenberg 1981). Animals show a wide range of behaviours during their lifetime, including perching, running, jumping, flying, climbing, crawling, hanging, resting, feeding, breeding, nesting, defending, foraging etc. These patterns are influenced by factors such as the distribution and quantity of

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significant tree species, seasonality, and the quality of their food supplies (Lambert 2010; Jaman and Huffman 2013). A trivial change in these factors can directly or indirectly cause a noticeable behavioural change, which can sometimes be responsible for their extinction (Hemsworth *et al.* 2015).

A deeper knowledge of such threats to species is crucial for saving them from extinction (Reid *et al.* 2008). In such situations, zoos can come to the rescue where animals are housed mainly for recreation, as well as for education, conservation, and research (Mench and Kreger 1996). Zoos contribute to conservation directly as well as indirectly through initiatives such as captive breeding, training for wild survival, and reintroduction (Zimmermann 2010). Zoos support the significant number of species required to support future wild populations and are at the center of conservation biology and education (Kumar 2021). The psychological and overall physical health of an individual in captivity is affected by several factors, including comfort, quality of food, and whether the cage is suitable for managing natural and instinctual habits (McPhee 2002; Mallapur and Choudhury 2003). The captive animals show differences in their natural activities that can lead to various complications for the rest of their lives, and they seem to exhibit abnormal reactions to any ecological or physiological factors (Jensen 1986; Jaman and Huffman 2011). The frequencies of these abnormalities vary depending on the degree of non-conformity of the habitat during the animal's life (Capucchio *et al.* 2019). Abnormalities in behavior were observed in both non-primates (Larsen *et al.* 2014, Bennett *et al.* 2015) and primate species (Mallapur and Choudhury 2003, Bentson *et al.* 2010, Henry 2019).

Among the ten non-human primates in Bangladesh, northern pig-tailed macaque (*M. leonina*) is assessed as Endangered species (IUCN Bangladesh 2015). They inhabit mixed evergreen forests in the southeast and northeast of the country (Feeroz 2001). *M. leonina* was studied by several researchers in Bangladesh and other countries of the world (Feeroz 2003; Mohd-Azlan *et al.* 2007; Albert 2013; Ahmed and Naher 2021; Singh *et al.* 2023), who focused primarily on details of the behavioral ecology in wild condition. Several authors also studied *M. leonina* (Mallapur and Choudhury 2003; Thanh and Nhai 2018; Solanki *et al.* 2020; Lalremruati 2020) in captivity, who focused mainly on the impacts of ecological factors on the behaviours, and comparative grooming patterns. The studies of captive primates and other animals may provide important biological and ethological information which are not always feasible to study in the wild. Moreover, very few research addressed the activities (Jaman and Huffman 2011) and abnormalities of the species in a semi-natural or controlled environment. As a result, it has become difficult to identify the

deviation of the behaviour of the species from their natural ones. This study could help in general welfare of captive *M. leonina* and serve as a model for the study of related species. The present study aimed to (1) construct behavioural profiles of *M. leonina* in captivity, (2) know diurnal and seasonal variations of different activities in captivity, and (3) focus on the possible factors related to the frequency and variation of behavioural activities of captive *M. leonina* at the Chittagong Zoo, Bangladesh.

MATERIAL AND METHODS

Study site and species: The study was conducted from October 2022 to May 2023 at the Chittagong Zoo, Chattogram of Bangladesh. The zoo is located between 22° 22′ 0″ N and 91° 47′ 46″ E. It is home to a total of 300 individuals belonging to 54 species, among them 25 species are mammals, 25 birds and the rest of 4 reptiles. We recorded the behaviours of five individuals (two females and three males) of *M. leonina* of different ages. The enclosure was mainly divided into two parts: an open area and another small cell. It had an area of 26 × 167 square feet approximately. The alpha male was confined in a separate smaller cage until March 2023 within the main cage for safety issues. There were large trees on both sides of the cage providing enough shade for the individuals. Two small water poles were available for drinking and bathing purposes. A double-layered wired net encircled the enclosure to reduce interaction between visitors and animals inside the cage.

Data collection and analysis: The diurnal activities were recorded from 09:00 to 17:00 hours on four days during the month. For normal behaviors, we recorded 14942 frequencies, while 2956 frequencies were noted for abnormal activities. A stopwatch and a structured datasheet were in aid for the data collection process. Photographs and videos were recorded for a better understanding of the activities. According to Altmann (1974), data were collected based on the scan sampling method with 5-minute intervals. An activity was recorded once in each scan. Daily activities were jotted down and enumerated four times a day (09:00- 11:00 h, 11:00 – 01:00 h, 10:00- 03:00 h, 03:00-05:00 h) and seasons (late autumn, winter, spring, and summer) (Biswas *et al.* 2014). We also used a structured ethogram in data collection based on previous behavioural studies (Melfi and Thomas 2005; Yanagi and Berman 2014; Fehlmann *et al.* 2017) (Table 1).

Data were assessed using the formula $T_a = (n_a \times 100)/N$ (Altmann 1974), where T_a = % of time spent on activity; n_a = number of records; and N = total number of records. We calculated frequency and percentage to understand diurnal and seasonal variation in behavioural patterns. For statistical analysis, a statistical program 'Past' (ver. 4.09 b) (Hammer *et. al.* 2001) was used. One sample t-test was used to evaluate the differences in activities, with a level of

significance at 5%. One-way ANOVA was also used to test the diurnal and seasonal differences in behavioural patterns. The Pearson correlation coefficient was used to test the relationship among behavioural activities.

RESULTS AND DISCUSSION

Behavioural patterns and their correlations: A total of 17898 observations were recorded; of which Northern Pig-tailed Macaque (*M. leonina*) spent most of their time (83.5%) in natural activities and the remaining time (16.5%) spent for abnormal behaviours. Out of 10 natural activities, the maximum time was spent on locomotion (46.11%), followed by resting (34.24%), grooming (6.26%) and feeding (3.83%) (Fig. 1a). The time spent in different natural activities did not differ significantly (t = 1.95, P = 0.08). On the other hand, self-biting, self-clasping, head tossing, eating debris, depression, stereotypic pacing, begging, biting cage bar and posterior presentation were observed under the abnormal behavioural category. Among these, the largest proportion of time was spent in depression (24.36%) and eating debris (24.22%) (Fig. 1b). Time spent in these activities also differed significantly within the pre-determined period (t = 3.62, P = 0.006).

Out of 45 correlation coefficients of normal behavioural patterns, only seven were found to be significantly correlated with each other. The significant correlation was found between aggression and mounting (r = 0.829, P < 0.5), affiliation and grooming (r = 0.919, P < 0.5), affiliation and fighting (r = 0.918, P < 0.5), aggression and fighting (r = 0.781, P < 0.5), mounting and fighting (r = 0.733, P < 0.5), grooming and fighting (r = 0.752, P < 0.5), grooming and vocalization (r = 0.728, P < 0.5). Moreover, out of 36 correlation coefficients of abnormal behaviours, significant correlation was found between self-biting and self-clasping (r = 0.904, P < 0.5), self-biting and depression (r = 0.725, P < 0.5), depression and self-clasping (r = 0.746, P < 0.5), self-biting and stereotypic pacing (r = 0.892, P < 0.5), self-biting and begging (r = 0.890, P < 0.5), begging and stereotypic pacing (r = 0.961, P < 0.5), somersaulting and biting cage bar (r = 0.937, P < 0.5).

Our results demonstrated that *M. leonina* spent the highest time in moving, which supports the previous findings of their activity patterns in semi-natural conditions (Singh *et al.* 2022). Prominent locomotory movements were also reported in other non-human primates (Monirujjaman and Khan 2017; Julianti *et al.* 2020; Naher *et al.* 2022). These frequent movement patterns may not be associated with resource accumulation in captivity, perhaps due to innate habits (Meyer *et al.* 1975; Erickson *et al.* 2005). *M. leonina* spent about 34.24% of their time resting, which was the second most time-consuming behavioural

Table 1. Ethogram of behavioural patterns observed in *Macaca leonina*

Category	Behaviour	Description
Locomotion	Walking	Moving on the ground with a walking pace from one place to another
	Jumping	Jumping off a high feature such as a building or post
	Climbing	Ascending by all limbs along the wired mesh
	Running	Moving with a galloping motion on the ground
	Hanging	Swinging on or from built structures
Affiliation	Playing	Positive interaction among individuals; manipulating objects
	Chasing	Running after one another without any aggression
Resting	Sitting	Resting on the buttocks
	Lying down	Lying down in any postures (dorsal, ventral or on the side)
	Standing	Motionless in a quadrupedal posture
	Sleeping	Napping or taking a long sleep by sitting or lying
Aggression	Biting	Using teeth as an attacking tool while fighting
	Wrestling	Grasping, pulling, rolling activities between two individuals
Grooming	Self-grooming	Inspecting and cleaning own body parts and fur
	Social grooming	Inspecting and cleaning the body parts and fur of the group members
Fighting	Inter-fighting	Aggressive encounters with individuals of adjoining cage species including hitting and vocalizing
	Intra-fighting	Aggressive encounters with individuals of the same species inside the cage including biting, wrestling and vocalizing
Vocalization	Aggressively	Producing loud sounds while fighting directed at one another
	Normally	Producing particular vocal sounds not associated with aggression
Mounting		Rising upon the back of another individual for copulation or ascertaining dominance
Abnormal Behaviour	Self-biting	Biting own body parts (forelimbs, hindlimbs, tail)
	Self-clasping	Holding or grasping own body parts by using fore or hindlimbs
	Somersaulting	Trying to flip towards and backward on the head
	Eating debris	Masticating the left-out dried food of the previous day, putting various wastes (lying in the cage) into the mouth
	Depressed	Indifferent to the surroundings and sitting in the same position sighting outside the cage
	Stereotypic pacing	Repetition of fast walking along the same route
	Begging	Stretching forelimbs towards the visitors carrying any bag or edible things
	Biting Cage Bar	Holding the bars of the enclosure by teeth with scraping
	Posterior presentation	Exhibiting the hindermost part of the body to the other individual in the middle of any activity

patterns in captivity. Monirujjaman and Khan (2017) reported that *Macaca mulatta* spent 50% of the daytime in feeding and resting in wild condition, followed by moving and other activities. Fleagle (1988) reported that folivores primarily spend most of their time resting. Jaman and Huffman (2013) mentioned that resting time was longer than other activities in captive Japanese macaque (*Macaca fuscata*) and activity budget was affected by enclosure environment. The common langur and other colobine species are reported as rest-performing primates (Khatun *et al.* 2011). However, several researchers found slightly different time spent of behavioural activities (Sayers and Norconk

Table 2. Sub-categories of natural behavioural patterns and their statistical variation in *Macaca leonina*

Category	Behaviour	*t*	*P*
Locomotion (n = 6890)	Walking (34.46%) Jumping (9.01%) Climbing (29.06%) Running (10.32%) Hanging (17.16%)	3.95	0.01
Affiliation (n = 288)	Playing (18.06%) Chasing (81.94%)	1.57	0.36
Resting (n = 5116)	Sitting (58.03%) Lying down (11.1%) Standing (16.46%) Sleeping (14.41%)	2.26	0.11
Aggression (n = 232)	Biting (54.31%) Wrestling (45.69%)	11.60	0.055
Grooming (n = 936)	Self-grooming (37.71%) Social grooming (62.29%)	4.07	0.15
Fighting (n = 234)	Inter-fighting (50%) Intra-fighting (50%)	-	-
Vocalization (n = 470)	Aggressively (43.83) Normally (56.17%)	8.10	0.08

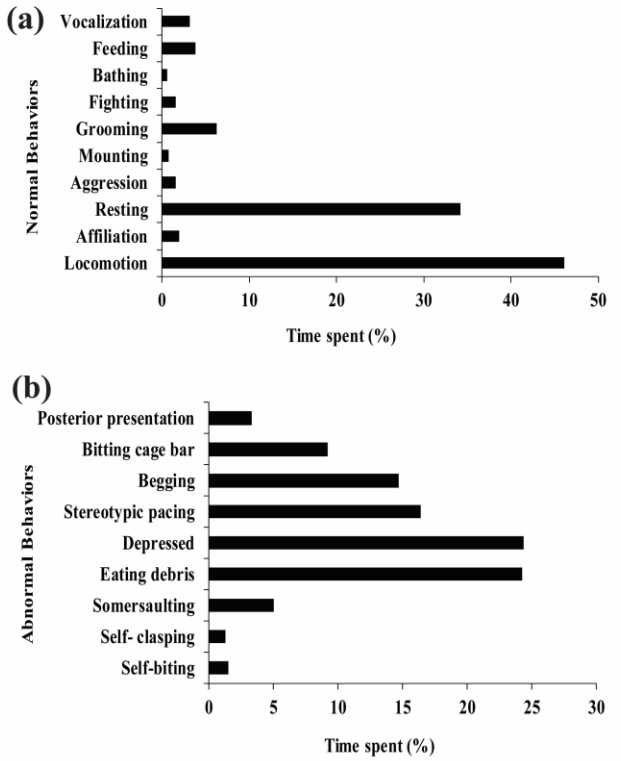

Fig. 1. Overall behavioural [(a) normal and (b) abnormal] patterns of captive *Macaca leonina*

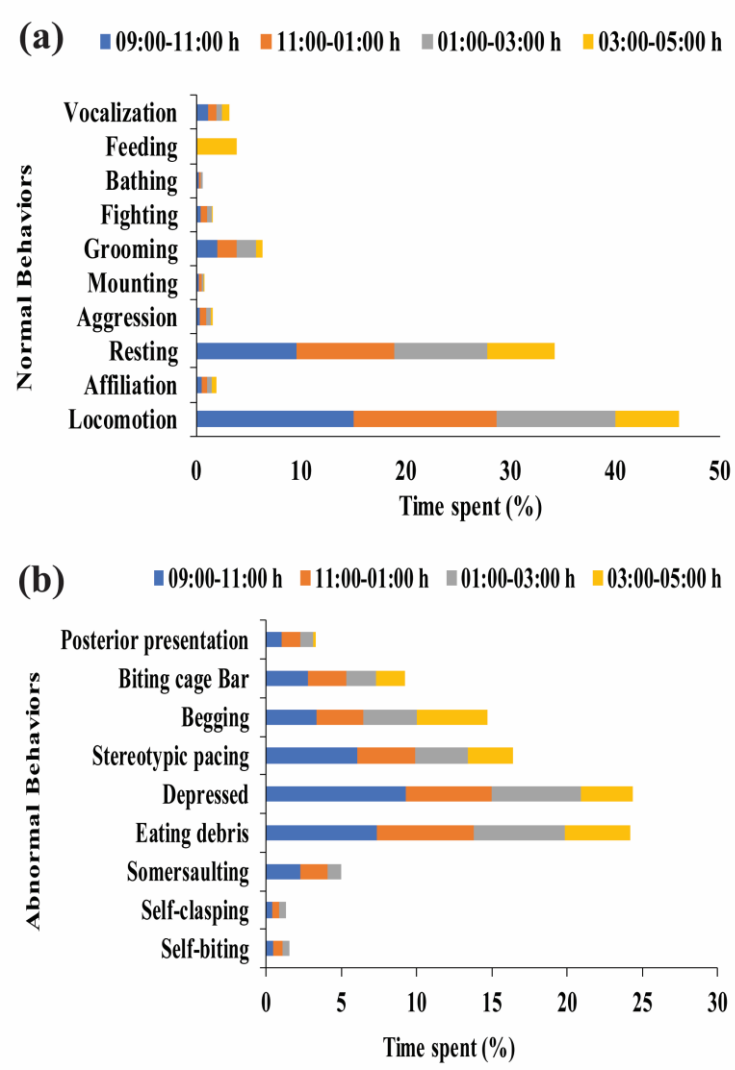

Fig. 2. Diurnal variation in the patterns of normal (a) and abnormal (b) behaviours of captive *Macaca leonina*

2008; Naher *et al.* 2022). The differences in behavioural activities might be associated with data collection procedures (Khatun *et al.* 2011). In addition, primate activity patterns are typically influenced by body size, foods, and other ecological resources (Naher *et al.* 2022) and variation in primate activity patterns is associated with change in their habitats (Cristóbal-Azkarate and Arroyo-Rodríguez 2007).

Affiliative interactions were observed between the juvenile and sub-adult, supporting previous studies (Fagen 1981; Roopnarine and Johnson 1994). In

our study, chasing dominance in affiliative interactions could be influenced by snatching garbage or food given by visitors. Aggression and fighting were sporadically observed in captive *M. leonina*. We also found a strong correlation of aggression with mounting and fighting. These patterns might be exacerbated by social isolation and resource scarcity (Xu *et al.* 2021). Similarly, Hall (1964) mentioned that baboons were less active in agonistic behaviors due to starvation. Temperature fluctuations and visitor numbers were identified as potential triggers for the aggressions (Mallapur *et al.* 2005; Hsiang *et al.* 2013).

Although *M. leonina* spent most of their time on common activities, some unusual activities were also observed. The depression was the highest unusual behaviour, followed by eating debris and stereotype pacing. The depression also showed a significant correlation with self-biting and self-clasping. Further, we found a significant correlation of stereotypic pacing with self-biting and begging. The isolation of alpha male, visitors, and lack of sufficient enrichment might have influence on these unusual behavioral patterns. In addition, providing sustenance once a day led to debris consumption and begging from visitors (debris includes rotten food from the previous day, packets of chips or peanut shells given by visitors). Previous studies also reported that several factors like rearing history, group structure, and cage design may influence these behaviors (Macedonia 1987; Mason 1991; Mallapur 2005). Additionally, isolated adult males exhibited signs of depression, which are characterized by sitting with their head bowed and a slight response to stimuli, consistent with observations in other species (Shively *et al.* 2006; Camus *et al.* 2013; Shively 2017).

Diurnal and seasonal patterns: The study species showed a gradual decrease in activities in the late afternoon (03:00-05:00 h) compared to the morning (09:00-11:00 h) for both normal and abnormal behaviours (Fig. 2a). Feeding was the only normal behaviour on which the macaques spent their time in the late afternoon. The macaques spent more time in affiliation, aggression and fighting activities during 11:00-01:00 h than in the morning (Fig. 2b). The individual variations of time spent in different time blocks were significant in both normal ($F = 29.95$, df = 30, $P < 0.0001$) and abnormal ($F = 17.00$, df = 27, $P < 0.0001$) behavioural patterns. *M. leonina* was more engaged in normal activities in late autumn (25.59%) than in summer (24.26%). Abnormalities were observed the most in late autumn, while at least in summer. A gradual fluctuation in both behaviors was visible from the beginning season to the last season studied. These normal and abnormal behavioural patterns differed significantly (normal behaviour: $F = 569.3$, df = 30, $P < 0.001$; abnormal behaviour: $F = 13.67$, df = 27, $P < 0.001$) across the four seasons.

Behavioural patterns for individual categories: Among the locomotory behaviours, *M. leonina* was engaged mostly in walking (34.46%), followed by

climbing (29.06%), hanging (17.16%) and least in jumping (9.01%) (Table 2). The time spent within different moving activities differed significantly (t = 3.95, P = 0.01). In resting activity, *M. leonina* spent the highest (58.03%) time in sitting, followed by standing (16.46%) and the lowest (11.1%) in lying (11.1%) (Table 2). The time spent within resting behavioural patterns did not differ significantly (t = 2.26, P = 0.11).

Regarding affiliative behaviours, playing and chasing were recorded, of which they spent the highest (81.94%) time in chasing. Out of two types of aggression behaviour, *M. leonina* used biting (54.31%) and wrestling (45.69%) (Table 2). In grooming activities, *M. leonina* allocated more time in social grooming (62.29%) than self-grooming (37.71%) (Table 2). The time spent in two grooming activities did not differ significantly (t = 4.07, P = 0.15). Moreover, *M. leonina* was found to vocalize more normally (56.17%) than aggressively (43.83%), which did not differ significantly (t = 8.10, P = 0.08). *M. leonina* was noticed to engage in fighting among group members and spend the same (50%) time in both intra-and inter fighting (Table 2).

Our study found that *M. leonina* spent the highest time in social grooming in captive environment. Previous studies also reported that social grooming is a common behavior in wild primates (Brown 2008; Minhas *et al.* 2010; Alam *et al.* 2014). Cheney (1987) reported that most of the primate species live in social groups, typically through interacting with each other within the group. A strong correlation of grooming was also observed with affiliation and vocalization in our study. In addition, self-grooming was also observed in the present study. Although self-grooming is normal behaviour in primates, it might be increased in captive environments due to the visitor influx in zoological garden. Pérez-Galicia *et al.* (2017), however, found a correlation between the visitor influx and self-directed activities in spider monkeys (*Ateles geoffroyi*). In the presence of visitors, captive primates have become more aggressive and social interaction has been observed to be decreased (Mitchell *et al.* 1991; Mallapur *et al.* 2005).

CONCLUSION

Our study provides initial insights into the behavioural patterns of *M. leonina* in captive environment. These might reflect their lifestyle preferences in the natural environment. Additionally, captive environment might affect their behavioural patterns. We therefore must maintain primates in appropriate housing and provide optimum food to avoid the development of adverse behavioural patterns in captivity.

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