Behavioural patterns of Western Hoolock Gibbon *Hoolock hoolock,* Asiatic Black Bear *Ursus thibetanus* and Asiatic Jackal *Canis aureus* at Bangladesh National Zoo

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DEDICATED TO MY BELOVED PARENTS

DECLARATION

I hereby declare that the thesis entitled **"Behavioural patterns of Western Hoolock Gibbon *Hoolock hoolock,* Asiatic Black Bear *Ursus thibetanus* and Asiatic Jackal *Canis aureus* at Bangladesh National Zoo"** submitted to the Department of Zoology, University of Dhaka for the award of the Degree of Doctor of philosophy has been composed solely by myself. The data analysis and interpretation are entirely the result of my own work, carried out in Bangladesh National Zoo under the supervision of Dr. Mohammad Firoj Jaman, Professor, Department of Zoology, University of Dhaka. I confirm that this thesis as a whole or part has not been submitted for any other degree at any University or professional qualification. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references has given.

Fariya Khatun

CERTIFICATE

This is to certify that the thesis entitled "Behavioural patterns of Western Hoolock Gibbon *Hoolock hoolock,* Asiatic Black Bear *Ursus thibetanus* and Asiatic Jackal *Canis aureus* at Bangladesh National Zoo" submitted by Ph.D. candidate under my supervision. She has conducted her work with full potentials and all the data, figures and parts presented in this thesis are based on her observation. The thesis or a part of it has not been presented for any other degree or used for any publication.

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ABSTRACT

Behavioural activities of mammals mainly have influenced by habitat types, foods, weather conditions and feeding competitions among individuals. To find out the behavioural patterns and the variation of behaviours in different time period of a day, months and seasons of Western Hoolock Gibbon *Hoolock hoolock*, Asiatic Black Bear *Ursus thibetanus* and Asiatic Jackal *Canis aureus* in captivity, the study was conducted at Bangladesh National Zoo. A total of 1648 hours were spent to collect 6556 scans during October, 2015 and October, 2017. In a day, the captive Hoolock Gibbon spent 40.54% time in resting, 12.42% in feeding, 17.79% in moving, 5.02% in grooming, 6.84% in playing and 17.39% time in other behaviour. The adult Gibbons spent more time (40.57%) in feeding than the sub adult (31.84%) during noon and the sub adult spent more time (19.20%) in moving than the adults (14.70%) in the afternoon. The captive Gibbons were more active in summer than the other seasons. The highest allogrooming (32.29% of time spent) was recorded in afternoon. Feeding was the highest (31.50%) in May and the lowest (20.30%) in January. The time spent was the highest in resting (31.80%), moving (29.50%) and grooming (29.40%) in the month of August, April, and December, respectively. The Asiatic Black Bear spent 55.63% time in resting, 16.50% in feeding, 11.55% time in moving, 3.42% in autogrooming and 12.90% in other behaviour. The Asiatic Black Bear spent the highest amount of time (37.34%) in resting and 38.33% time in feeding in winter but the moving and grooming time were the highest in summer, 38% and 43.30%, respectively. The highest feeding (30.50%) and resting (31%) time was recorded in December. The Asiatic Black Bear spent more time in moving (30.50%) but less time in feeding (17.30%) and resting (19.30%) in May. In a day, the Asiatic Jackal spent 12.52% time in feeding, 29.29% in moving and 15.43% in resting and 42.76% time in other behaviour. They spent the highest time in resting (37.33%) and feeding (36.32%) during winter and moving (38.33%) during rainy season. The highest time investment in feeding (26.75%), resting (26.50%) and moving (26%) was recorded in January, December and August respectively. The activities were significantly varied in relation to temperature. Conservation and reintroduction program of captive animals can be enhanced through the research on the behavioural well-being of captive animals. Thus, this study can be proved fruitful for the behavioural enrichment and welfare of the captive zoo animal.

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Chapter 1

INTRODUCTION

Wildlife provides stability to different natural processes of nature and ultimately maintains the ecological balances of the environment (Jacobs 2018). But it is a matter of great unfortunate that primates are in peril (Estrada et al. 2018). The worldwide rapid reduction of wild population has become a matter of major global concern over the past few decades. The scenario is same in case of Bangladesh in this regard (Mukul et al. 2017). Unfortunately, the number of wild species has already declined by more than 50% (Morelle 2016). It is thus crucial to have scientific knowledge about existing species, their habitats, threats, etc. for undertaking pragmatic protection and conservation measures. In this regard Zoo plays an imperative role. Zoos are attractive places to study where collections of attractive and common as well as rare animals are available, also source of prospective research that allow to enhance scientific knowledge about the biology of wild animal and their management in captivity (Bishop et al. 2013). Zoo emphasizes on conservation especially for species that are threatened or at risk of extinction as to reintroduce safely the threatened species in the wild they are kept in captivity (Bowkett 2009). The reintroduction of wild animals is possible by keeping individuals of an endangered species in captivity, by creating a population reservoir and through breeding programs. For the conservation of threatened species, since 1990s Zoos are playing an important role (Ryder and Feistner 1995).

To ensure survival in the wild, there is a critical importance in gaining a greater understanding of the lives of rare and threatened taxa (Reid et al. 2008). Safeguarding of populations of threatened species in the wild requires considerable knowledge of the biology of each species. Zoo is the place that allows researchers to investigate how the wild animals behave while keeping in captivity. Through the scientific research based on zoos animal, one can obtain knowledge about animal behaviour, habitat nature, mating behavior, nutrition requirements, group dynamics, parasitology, husbandry and reproduction cycles. This scientific knowledge can be proved fruitful for the wildlife conservation.

Mammals are often considered to be the most advanced form of life on earth (Golley 1966) and play an important role in the food chain and ecosystem by providing essential ecological services such as regulating insect populations, seed dispersal and pollination and act as indicators of general ecosystem health (Jones and Safi 2011). Some species are vitally important in bio-

medical and other scientific research (Vaughan et al. 2000). The study of nonhuman primates (monkeys and apes) has opened broad new areas of research relevant to human welfare. Mammals are also important for the ecotourism industry. Many people travel to zoos or to all corners of the world to see animals like monkeys, bears, elephants, lions, tigers, jackals, snakes, crocodiles or kangaroos etc (Vaughan et al. 2000).

According to the IUCN-Bangladesh (2015), there are 127 species of mammals belong to 35 families under 9 orders are found in Bangladesh, among which 17 species are categorized as critically endangered, 12 are endangered, 9 are marked as vulnerable, 9 are near threatened and 34 species are recorded as Least Concern. In Bangladesh, 10 species of non-human primates are found including Loris, Macaques, Langurs and Gibbon (Feeroz et al. 2011, 2013, Hasan et al. 2013).

1.1. Western Hoolock Gibbon

The Western Hoolock Gibbon (*Hoolock hoolock*) is globally endangered primate species and in Bangladesh it has been listed as critically endangered (IUCN-Bangladesh 2015), belongs to the family, Hylobatidae. They are about 31.97 inches (81.2cm) tall and the weight of male is around 6.9 kg and the female's weight is about 6.1 kg (Leutenegger and Cheverud 1982). The lifespan in captivity is about 41 years (Weigl 2005). Adult male and adult female Hoolock Gibbon show distinctively variation in pelage colouration (Schultz 1973) while males and young female are black in color. Whereas the matures females are creamy whitish color with dark hair on the chest and neck. Body color of young female changes during later phases of maturation in contrast to females of other species of the subgenus (Groves 1972). Hands and feet are thin and long with an opposable thumb and big toe for their well-known mode of locomotion, called brachiation (Vereecke and Aerts 2008), as their hook-like digits permit them to hang without wasting much energy while staying motionless like when they forage (Abram 2019). Being a frugivorous about 89% of their food comprises of fruits (Islam and Feeroz 1992). Shoots, bark and animal prey are consumed largely at the end of winter when other food items and even water were in short supply (Neha et al. 2020). Hoolock Gibbons mostly forage on the trees from fig family (Neha et al. 2020).

They are strictly arboreal (Grand 1972), can swing from trees to trees but also can walk upright on two legs (bipedal locomotion) like human (Crompton et al. 2008). Through howling they attract mates and announce to neighboring groups that the occupied territory is forbidden

(Cowlishaw1992). Thus, the best way of communication of Gibbons is howling. These songs can be heard several miles away (Abram 2019). Gibbons share strong monogamous family bonds (Chivers 2005). Coupled Gibbons stay together for several years. Families are usually composed of one adult male and one adult female and their offspring (Brockelman et al. 1998, Geissman 1991, Leighton1987, Reichard and Barelli 2008). When the male and females become sexually matured usually at age of 8, they leave their family to start their own (Gittins and Tilson 1984).

Hoolock Gibbon dwells in dense tropical evergreen rainforests, subtropical broadleaf hill or mountain forests and subtropical monsoon evergreen broadleaf forests (Abram 2019). Their occurrence in deciduous forest and scrub forest is limited while there is no trait in mangroves (Gittins and Tilson 1984, Choudhury 1996). But prefer the mixed areas and pockets of evergreen forests (Choudhury 2009a, 2009b). At elevation of 80-1500m Hoolock Gibbons are mostly occurred (Mukherjee1986, Choudhury 1996). However, they have been documented up to 2,550 m in Manipur (Choudhury 2001).

The distribution of Western Hoolock Gibbon comprises of the dense forests that extend from Sylhet, Chittagong and hill tract of Bangladesh, east of the Brahmaputra River in northeast India, Indian states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, and into western Myanmar west of the Chindwin River (Groves 1967). There was significant change in the classification of Gibbons over the years. Typically, all Gibbons, including the hoolock Gibbons, were classified in the genus Hylobates. Then siamangs were parted in to their own genus, *Symphalangus* by Goodman 1999. On the basis of anatomical, vocal and karyotypic assessments of hoolock with other members of the subgenus *Hylobates*, Groves (1972) positioned hoolock in the subgenus *Hylobates*. Based on the result of recent investigations it was determined that there was no close relationship between the Hoolocks and *Bunopithecus sericus* and Hoolocks got their own genus, Hoolock. Although *Bunopithecus* was classified as the hoolock subgenus different from other Gibbon subgenera. There are two identified subspecies, *H. hoolock hoolock* (western) (Harlan and Burrough 1834) and *H. hoolock leuconedys* (eastern) (Groves 1967).

1.2. Asiatic Black Bear

Asiatic Black Bear (*Ursus thibetanus*) is one of the endangered species in Bangladesh (IUCN Bangladesh 2015). Asiatic Black Bear (*Ursur thibetanus*), belongs to the family of Ursidae (Kosintsev et al. 2016). They live in the wild up to 25 years while in captive condition their life span is more than this, the oldest Asian Black Bear in captivity died at the age of 44 (Brown 1993). The male and the female bears are distinguishable by their size of the body (Bob Humphrey 2018). The weight of male usually between 60 and 200 kg with an average of about 135 kg, whereas the female's body weight is 40 to 125 kg (Macdonald 2001). They have a strong and sturdy body with a short tail that can hardly be seen and short but powerful limbs (Goodness 2004). The body is 120 to 180 cm. in length and with an extra 11cm. for tail (Brown 1993). The large and rounded head is with small eyes, ears are large, erected and are placed characteristically apart from each other (Huber and Manen 2019). However, according to Huber and Manen (2019) the claws of the fore limbs are slightly longer than that of the claws of hind limbs. The coat colour of Asiatic Black Bear is black and there are distinctive white patches on the chest with a shape of "V" or moon shaped hence got the name moon bear or white chested bear (Stirling et al. 1993). The larger appearance of bears is due to the ruff fur around their neck (Kemmerer 2015). Asian Black Bears are diurnal, but near human locality they show nocturnal activities (Swanson 1990, Bridges et al. 2004).

Although the Asiatic Black Bears are classified as carnivores but they show omnivorous diet (Laura 2008). Being omnivorous their food comprises of insects, beetle larvae, invertebrates, termites, bamboo shoots and leaves, grasses grubs, carrion, bees, eggs, garbage, mushrooms, grasses, fruits, nuts, seeds, honey, herbs, acorns, cherries, dogwood and grain (Brown 1993). The Black Bears are also reported to feed on domestic sheep, cow buffalo (Yadav et al. 2019). Asian Black Bears are opportunistic omnivores and adapted for a nutritional bust economy (Yadav et al. 2019). They can eat available seasonal food and store extra calories and go in to hibernation and be prepared for the times of scarcity (Schaller et al. 1989). The bears have extended nose which is the reason of their unusual sense of smell, that is a means of communication with the members of their own kind for instance they urinate or defecate or rub the body against trees to leave their sent so that the other members can easily trace them (Sergiel et al. 2017). Larger

males can mate with the female which means a trend is followed on the basis of age and body weight (Lariviere 2001). Gestation period is 6 to 8 months and at the age of three years the females have their first litter (Servheen et al. 1999) and during birth the cub's weight is 8 -10.5 ounce (Goodness 2004). Usually 2 cubs are born (but the number can be 1 to 4) (Brown 1993). They are born blind and helpless and opens their eyes few days later (Brown 1993).

The habitat of Asiatic Black Bear dwells in broadleaf and coniferous forests, deciduous forests thorn brush, foothills and mountain regions with thick vegetation at lower altitude (Choudhury 2013). While having food on the trees they make a nest like structure on their tops by breaking the branches surrounding them to keep themselves under the nest (Servheen et al. 1999). After finishing the food, they take rest for short period in the nests (Brown 1993). Their dens may be caves or holes in the ground, hollow logs or steep, mountainous and sunny slopes or may be abandoned other bear's dens (Brown 1993).

The Asiatic Black Bear is mostly distributed throughout the Asia (Ahmadzadeh et al. 2008). The range is from Bangladesh (IUCN Bangladesh 2000), Iran, Afganistan, Pakistan, across the foothills of the Himalayas, India, Myanmar and Southeast Asia (Sathyakumar 2001) According to the study conducted by the Islam et al. (2013) the bears were traced in Rajkandi, Jungle Bari, Patharkhola, Nahar Punji, Sheshil Bari, Longlia Punji, Mecharnicheera, Horinchara, Biddabeel, Shibbari, Horinchara 87 sector, Horinchara 10 sector, Valukuchi, Nirala Punji, Kuttamara, Alubari, Sukcheera, MohaDebtila, Chalta Punji, Nihar Tea Garden, Tiracheera and Aslam Punji in Maulivi Bazar while Satchari National Park in Habiganj district of Bangladesh. They were also reported to be found in Bancharain, Sreemangal and areas in the Maulvi Bazar district in the Sylhet division, from Khagrachhari, Kassalang, Bandarban, Dulahazara, Naikhongchhari, Cox's Bazar and Teknaf in the greater Chittagong division (Sarkar 2006).

1.3. The Asiatic Jackal

The Asiatic Jackal (*Canis aureus*), has been categorized as least concern in Bangladesh (IUCN Bangladesh 2015). The Asiatic Jackal or golden Jackal with its changeable dusky yellowish colored body is a canid belong to the order carnivora is a representative of the genus Canis (Clutton-Brock et al. 1976) and sexual dimorphism is present in body size and weight (Raichev et al. 2017). The length of the male Jackal is 71-85 cm while the female is 69-73 cm in length, the

male's body weight varies from 6-14 kg whereas the female's is between 7 and 11 kg the shoulder height of both sexes is 38-50 cm (Ginsberg and Macdonald1990). The trunk is elongated with pointed and narrow snout and muzzle (Heptner 1998) and the forehead is less-prominent with the German shepherd's long, alert ears (Boskovic et al. 2015). The life span of Asiatic Jackal in the wild is 8 years on average (Wallis 2019) while in captivity they can live up to 14 years (Sillero-Zubiri et al. 2004).

The Jackals have strong canine and carnassial teeth facilitating their feeding habit (Stan 2016). Sometime a horny growth called "Jackal's horn" measuring 1.3 cm in length develops on the skull, is hidden by fur (Eberhart 2002). This possession was thought to be associated with magical power in Sri Lanka. The fur of Jackal is uneven and comparatively short (Clutton-Brock 1976). Some Jackals have light marking on the chest and throat (Sillero-Zubiri et al. 2004).

Asiatic Jackal is an opportunistic, cooperative, cunning predator, scavenger and omnivorous can adjust with the available food in different season (Wyman 1967, Moehlman 1983). Macdonald (1979) demonstrated that the Jackals prefer easy human made food manage to survive almost entirely on garbage and human wastes. The foods of Jackal comprised of rodents, hares, birds, reptiles and the meat left by the tiger, lion, leopard of wolf, mollusks, insects, different types of fruits and vegetables (Roberts 1997).

Usually, the breeding pair makes a social group with the litter consisting of 1-9 pups usually 5-6 (Ginsberg and Macdonald 1990). From December to April breeding pair is formed, then the howling increases and in canids howling is a means of announcing of territory and defending method (Harrington and Mech 1979). The adult Jackals howl standing while the young and sub adult howl sitting (Lapini 2009). The Jackal follows a monogamous trend of family (Heptner 1998).

Asiatic Jackal is abundant in South Asia; Bangladesh (Poche et al. 1987) Afghanistan, Bhutan, India, Nepal, Pakistan (Rosevear 1974, Kingdon 1977, Roberts 1977, Prater 1980) and Sri Lanka (Sillero-Zubiri et al. 2004). In Central Asia, Southeast Asia; it inhabits in Myanmar and Thailand (Sillero-Zubiri et al. 2004). In Southwest Asia; it resides in Iran, Iraq, Israel, Jordan Yemen (Rosevear1974, Kingdon 1977, Roberts 1977, Prater 1980). In Europe; it occupies Austria,

Bulgaria (Genov and Wassiley 1989, Sheldon 1992), Croatia, Greece, Italy, and Albania (Rosevear 1974, Kingdon 1977, Roberts 1977, Prater 1980).

The population of Hoolock Gibbon has been steadily deteriorated by more than 90% in the wild because of several kinds of human actions (Walker et al. 2007). Several studies on population and behavioural ecology of Hoolock Gibbon have been conducted in India (Choudhury 1990, 1991, 1996, 2001, 2004, 2006, Das et al. 2004, Kakati 2004, 2006, Gupta and Sharma 2005) and Bangladesh (Islam 1992, Ahsan 1994, Feeroz 2001, Hasan et al. 2005, Muzaffar et al. 2007, Hasan and Feeroz 2011 and Akers et al. 2013).

Studies carried out on human and bear confliction in Pakistan by Ali et al. 2017, on status of Asiatic Black Bears in protected areas of Nepal by Stubblefield (2007), on the feeding habit of bear in Japan by Hashimoto and Anrui (2017) and on the distribution of bear Rounds 1987. Few studies on Black Bear have been done in Bangladesh (Bear Specialist Group 1996, IUCN Bangladesh 2015, Khan 1982, 1985). Several studies have been done on Asiatic Jackal in different parts of the world, for example in Greece on the diet of Asiatic Jackal by research was carried out by Giannatos et al. (2010), on status survey and conservation action by IUCN (2004) and Singh et al. (2016), on the feeding habit by Lanszki and Heltai (2002); whereas in Bangladesh, few studies were done on Asiatic Jackal (Poche et al. 1987, Jaeger et al. 1996, 2007). But these researches are mostly based on status, distribution, ecology, conservation and feeding habits. But no work has been done in Bangladesh National Zoo on the behavioural patterns of these selected species yet.

Animal welfare is achieved when an animal can cope up with the conditions in which it lives. In captivity numbers of factors like feeling, quality of the food (whether it is appetizing, satisfying, nutritionally suitable or not), level of comfort, the appropriateness of the cage to carry out natural and innate behaviours, affect psychological and general physical well-being of the individual (Mcphee 2002). The response to a varying degree of factors affecting the survival and reproductive success is represented as an animal's activity budget (Defler 1995). The activity budget is related to the day-time available and primate must carry out conservation behavior in addition to pursuing its social activities (Altmann 1980). Through activity budget the distribution of available time by the animal among different activities that are crucial for its survival and reproduction can be known which also recommends how a species exploit resources and cope up

with its environment (Bernstein 1980). In captivity in order to evaluate a behavioral management technique for an animal, it must be kept in mind that the population housed in cage is diverse and the response to management potentially is influenced by various factors as age, rearing, and prior social experience.

The captive environment differs vastly for an animal from the environment and life for which they are innately prepared thus their always remain a probability of concentrated welfare like, having no scope or no necessity of showing those behviours that are means of success in wild natural habitat (McPhee 2002). Through the natural behaviour shown by the displayed animals, zoo visitor naturally can get real concept about the animal, that is a viable representative of its wild counterparts. A caged individual needs to change its behavior according to feeding schedules or conspecific groupings. The response to future management tools of zoo depends on how an animal learns and change the behaviour while rearing up in the captive environment (McPhee and Carlstead 2010). Specific behviour like greater tolerance of loud noises ensure the highest chance of survival in captive management programme. Studies of behviour is worth some method to evaluate the overall welfares of animal in zoo. Behaviour is the reflection of an animal's first efforts to manage with a difficult situation and thus may indicate a state where welfare is at threat earlier than any known degree of physiology or pathology (Dawkins 1998). Behaviors like diurnal and seasonal behaviours like resting, feeding, moving, calling and grooming can be proved fruitful for the assessment of welfare of zoo animal. Hereafter, for understanding behavior and activity patterns such behavioral studies can play vital role and can ensure successful captive management of a caged species.

In this research work a quantitative analysis of activity budget of the selected captive species Western Hoolock Gibbon (*Hoolock hoolock*), Asiatic Black Bear (*Ursus thibetanus*) and The Asiatic Jackal (*Canis aureus)* had been carried out based on diurnal, monthly and seasonal fluctuated observation which is very important to understand the nature of the adaptive strategy of the species and hopefully that will play an important role in the conservation of the species.

Severe habitat loss due to fragmentation, poaching, increased human settlements, shifting husbandry, unregulated slaughter for sport, the existing population are at the verge of extinction (Rija et al. 2013). To increase their number reintroduction are very imperative. To make these

programs fruitful having proper knowledge about their behaviour, requirements adaptive skills and other important aspects about the life of species is essential.

Keeping the above criteria in view, this study had been proposed which was supposed to provide baseline information about activity patterns for the selected mammalian species housed in Bangladesh national zoo Mirpur, with the expectation that the data would be proved prolific for the welfare of zoo mammalian species, to improve the captive condition and thus help for the conservation.

1.4. Objectives of the study

The study was initiated with the following main objectives;

1. To find out the baseline information on the behavioural activities of the target species in captivity.
2. To know the variation of activity patterns in different age-sex classes in captivity.
3. To know monthly and seasonal variation of different activities in captivity.
4. To study diurnal variation of activity pattern in captivity.
5. To investigate how behavioural activities are influenced by various factors in captive environment.

Chapter 2

STUDY AREA

2.1. Study site

The study was carried out in the Bangladesh National Zoo, Mirpur, Dhaka during October, 2015 to October, 2017. The Dhaka Zoo was first initiated in 1950, with spotted dears, monkeys and elephants near the Dhaka high court because of the growing interest and passion for the protection, conservation and exhibiting the existing wildlife species in Bangladesh (Dhaka Zoo 2020). Then in 1960, the Zoo was transferred in Mirpur area near the Turag river. In 1961, a board was prepared to make sure proper management of the zoo (Dhaka Zoo 2020). After the liberation war, in 23 June 1974 the Zoo was inaugurated (Dhaka Zoo 2020). In 5 February 2015, the name of the Zoo has been changed from its former name Dhaka Zoo to Bangladesh National Zoo (Swin 2015).

2.2. Area

The total area of the Bangladesh National Zoo is 75 ha (Dhaka Zoo 2020). Two artificial lakes were created according to the well land plans which purely enhanced the natural beauty of the zoo.

2.3. Location

The Bangladesh National Zoo is situated at Mirpur, 16 kilometers north-west from zero point of Dhaka, Bangladesh. The red marked place in the Fig. 2.1 indicates the location map of the study area (Source: Dhaka maps, 2016). The geographical position of the Bangladesh National Zoo is 23° 48′ 45.62″ N and 90° 20′ 40.6″ E. The National Botanical Garden is located at the north side of the Zoo.

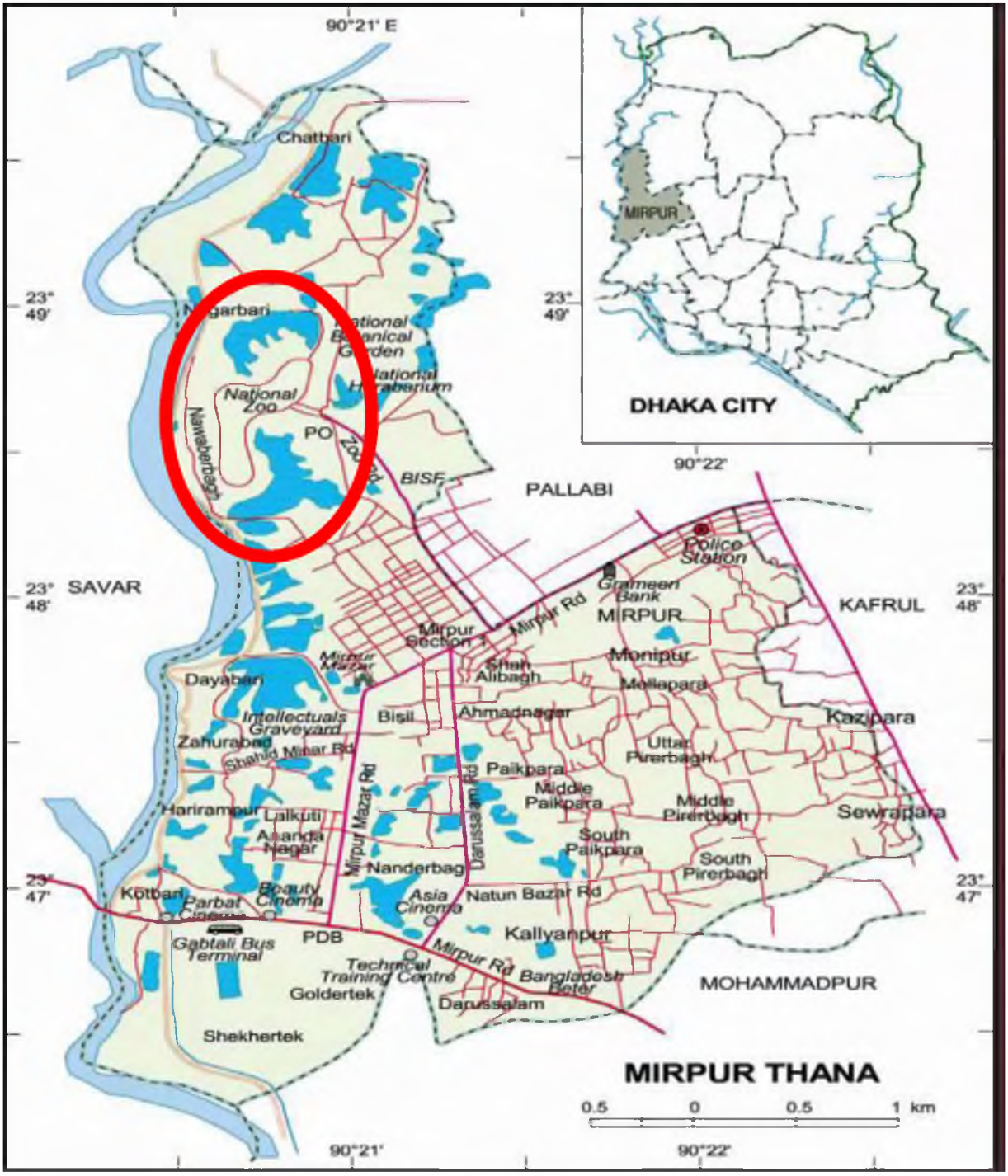


Fig. 2.1. Location map of the study area. (Source: Dhaka maps 2016)

2.4. Climate

Dhaka experiences a hot, wet and humid tropical climate. The hottest temperature was in April and January was the coldest month (Fig. 2.2). From November cold weather usually initiates and terminates at the end of February. Annual average rainfall was 2490 mm. in Dhaka in 2017 (Bangladesh Water Development Board 2019). Most of the rainfall occurs during April to October.

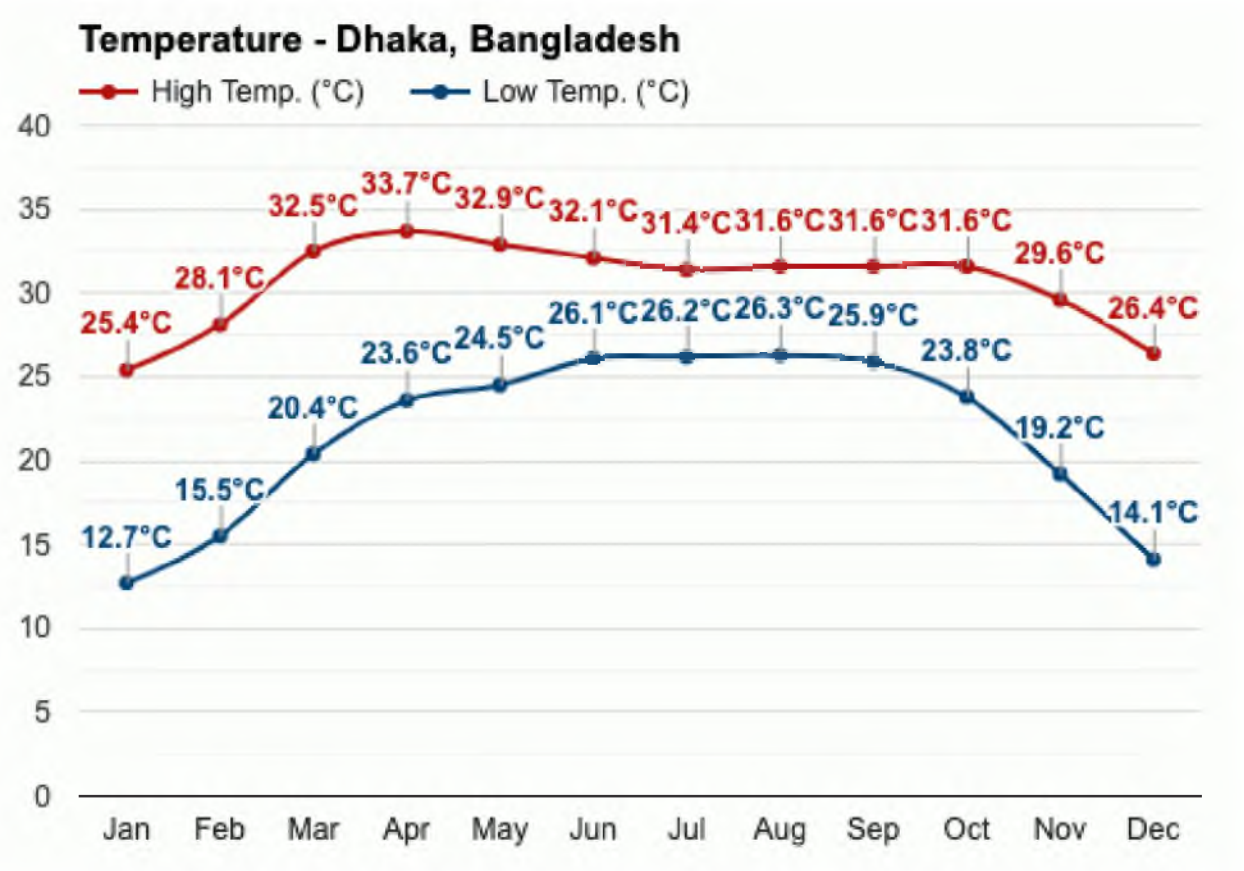


Fig. 2.2. Maximum and minimum temperature of the Dhaka city. (Source: Dhaka meteorological department.)

2.5. Fauna of Bangladesh National Zoo

The Bangladesh National Zoo is the home of 134 species (2150 individuals) of wild animals including reptiles, birds and mammals (Dhaka Zoo 2020). Among the mammals elephant, cheetah, rhinoceros, zebra, waterbuck, otter, hyena, deer, giraffes, impala, black bear, tapir, hippo, lion and many different species of monkeys, as well as chimpanzees and baboons are kept in this zoo.

Fig. 2.3. Guide map of the Bangladesh National Zoo. (Source: Bangladesh National Zoo map 2018)

Peacocks, rhea, African grey parrots, cassowary, owls, ostrich, emus, teals, finches, babblers, owls vultures and eagles are most mentionable. Visitors are always fascinated by the crocodiles and snakes at Dhaka Zoo, while the museum provides many informative displays relating to the animals as well as the history of the zoo. An elephant-back ride and horse-back ride are also available. There is a guide map (Fig. 2.3) at the adjacent to the entrance of the zoo that helps the visitors to find out the direction and location of specific cages.

2.6. Vegetation of Bangladesh National Zoo

The flora such as Rain tree *(Samania saman)*, Sissoo *(Dulbergia sissoo)*, White siris *(Albizia procea)*, Jack fruit *(Artocarpus heterophylla)*, Mahagony *(Swietenia mahogany)*, Hizal *(Barrintonia acutangular)*, Mango tree *(Magnifera indica)*, Banana tree (*Musa sapientum)*, Coconut tree *(Cocos nucifera)* and Bot tree/Banyam *(Ficus benghalensis)* are enhancing the natural beauty of the Zoo.

2.7. Management

Different sections of the zoo are controlled by subordinate officers and staffs also who help them to render the service efficiently. Ministry for Fisheries and Livestock regulate the advisory committee of the zoo as a proper guidance of zoo authority ("Dhaka Zoo". world66.com). The zoo is also run successfully for breeding program of different species specially on the tiger, lion, leopard primates deer, pythons and some species of birds. There is an information Centre from where the necessary information has been providing for the zoo visitors.

Chapter 3

MATERIALS AND METHODS

3.1. Methods

3.1.1. Study animal

Data on behavioural activities were collected from October 2015 to October 2017 for 3 individuals of Hoolock Gibbon, 4 individuals of Asiatic Black Bear and 9 individuals of Asiatic Jackal. In captivity, among the 3 individuals of Hoolock Gibbon, one adult female with one sub adult female were kept in one enclosure and the other adult female was kept in another enclosure. The enclosure was constructed by metal wire measured 7.87 m length × 4.72m width × 4.17 m height with muddy floor (Fig. 3.1). There was an interlinked compartment where the Gibbons had free access. The food and water were supplied in this compartment measured 6.30 m length × 3.15 m width × 4.12 m height. In between the two cages a gate of 1.52 m × 0.91 m was present. There was a boundary of 1.52 m surrounding the cage.

Four female individuals of bears were kept in three semicircular enclosures measuring 99.90 m^2 with a height of 5.74 m (Fig. 3.2). The bears had free access to an off-exhibit area in which their food and water were given measuring 6.71 m × 3.05 m. there was a 1.83 m boundary around the cage. Half part of the floor of the cage was bricks while the other part was sandy.

Nine individuals of Jackal were sheltered in 4 cages but the cages were adjacent to each other. The measurement of each cage was 4.88 m × 3.51 m × 3.05 m (Fig. 3.3).

Fig. 3.1. Cage of *Hoolock hoolock* at Bangladesh National Zoo.

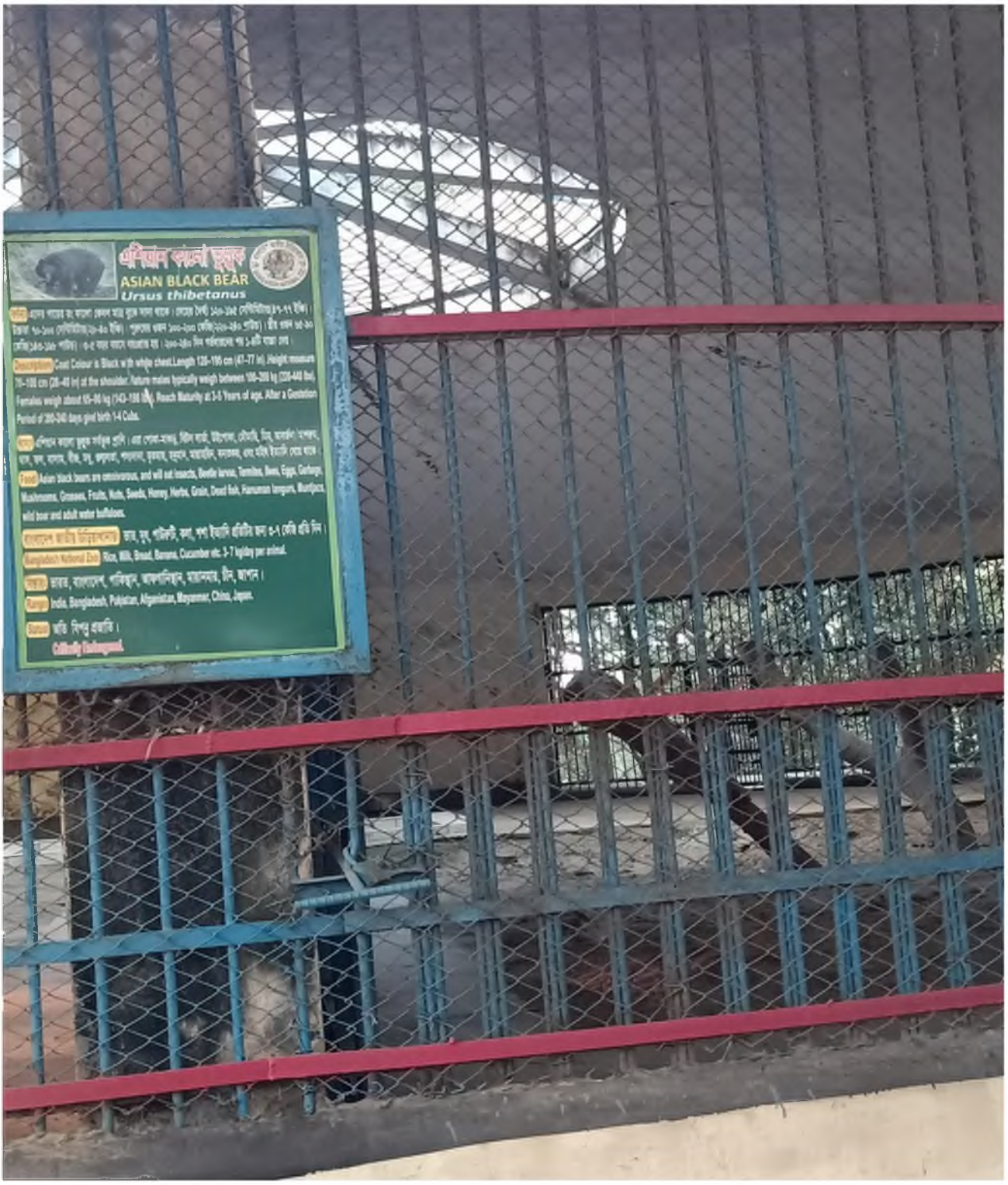


Fig. 3.2. Cage of *Ursus thibetanus* at Bangladesh National Zoo.

Fig. 3.3. Cage of *Canis aureus* at Bangladesh National Zoo.

3.1.2. Data collection

Behavioural data were recorded by scan sampling method at 5 minutes interval followed by Altman (1974). As the study was conducted in captive condition so the data was collected only during day time period from morning to afternoon according to the zoo's visiting time schedule.During this study a data sheet was prepared to collect the data of the behaviours. Ethograms defined as follows;

Feeding: The intake of solid foods or water into mouth, chew and swallow food is termed as feeding (Hasan et al. 2007).

Locomotion: The terrestrial or arboreal moving of an animal either with definite direction or not is called as locomotion (Hasan et al. 2007).

Resting: When animals spend time doing nothing (remain inactive) like no feeding, foraging, moving or grooming then this is termed as resting (Hasan et al. 2007).

Grooming: Grooming is one kind of social activities called when one or more animals involve in picking out, scratching or removing of debris, ectoparasites or other objects from the fur or skin of oneself or others (Hasan et al. 2007).

Playing: One kind of social behaviours (Hasan et al. 2007).

A total of 1648 hours were spent to collect 6556 scans for three species, of which 623.5 hrs were spend to collect 2494 scans for Hoolock Gibbon, 750 hours were spent to collect 2964 scans for Asiatic Black Bear and 274.5 hrs to collect 1098 scans for Asiatic Jackal (Table 1). All observations were made when the zoo was open to visitors, beginning at the hour of zoo opening and ending at the hour of zoo closing. Observation periods were divided into three different time blocks, morning (10:00-12:00), noon (12:01-14:00) and afternoon (14:01-16:00) (Shire 2012). About 3 days, 4 days and 2 days per week were spent on Asiatic Black Bear, Hoolock Gibbon and Asiatic Jackal respectively. Observation days and periods varied in different months and seasons

due to longer and shorter day time period. Data were collected in different seasons (summer: March to June, rainy season: July to October and winter: November to February) (Feroz et al. 2020).

Table-1 Records for behavioral scanning on Western Hoolock Gibbon, Asiatic Black Bear and Asiatic Jackal between November, 2015 and October, 2017.

Months	*Hoolock gibbon*		*Ursus thibetanus*		*Canis aureus*	
	Total scan	**Observation hour**	**Total scan**	**Observation hour**	**Total scan**	**Observation hour**
November, 2015	128	32	224	56	-	-
December	72	18	120	30	-	-
January, 2016	104	26	156	39	-	-
February	144	36	288	72	-	-
March	102	25.5	238	59.5	-	-
April	228	57	190	47.5	-	-
May	100	25	80	20	60	15
June	54	13.5	72	27	72	18
July	132	33	88	22	88	22
August	130	32.5	130	32.5	52	13

Months	*Hoolock gibbon*		*Ursus thibetanus*		*Canis aureus*	
	Total scan	**Observation hour**	**Total scan**	**Observation hour**	**Total scan**	**Observation hour**
September	100	25	120	30	20	5
October	52	13	140	40	28	7
November	120	30	208	52	40	10
December	108	27	36	9	72	18
January, 2017	132	33	88	22	44	11
February	100	25	100	25	40	10
March	96	24	120	30	72	18
April	48	12	112	28	32	8
May	122	30.5	96	24	118	29.5
June	74	18.5	56	14	38	9.5
July	124	31	110	27.5	78	19.5
August	92	23	96	24	76	19
September	68	17	84	21	88	22
October	64	16	72	18	80	20
Total time spent	2494	623.5	2964	750	1098	274.5

3.2. Materials

During the study period data of temperature were collected from Dhaka meteorological department (Fig. 2.2). The number of visitors near the enclosures was manually counted during scan interval. Digital camera was used to collect photographs of different activities. Meter tape was used to take measurement of the enclosures of studied animals.

3.3. Data analysis

The analysis included four samplings per hour to record the stated behaviours. The percentage of behaviour was estimated using the formula, $B = \frac{n\,x\,100}{N}$ where, B= behaviour (%), n= the sum of total number of time that the behaviour occurred during each observation, N=total time of each observation (Neha at el. 2020). By averaging the four scans, the hourly data was determined which provided the data for the diurnal and then monthly activity. Finally, the seasonal data were estimated according to the mean value of the relevant months (Neha at el. 2020).

ANOVA test was applied to know the mean variance in behaviours among the three different time blocks. To understand whether the time spent in different activities across the months was significant or not, ANOVA F-test was conducted. To find out the differences of behaviours between the groups T-test was used. Correlation was used to assess the relationship between the behaviours. Results were evaluated at the 5% level of significance (P=0.05). MS Excel (2016) and IBM SPSS Statistics (version 22) were used to analyze the data. Total number of observed hours for each animal, for each behavior (feeding, resting, moving and grooming) and the amount of time engaged in a behavior by each animal as well as the percent of the total observed time were observed through MS Excel.

Chapter 4

RESULTS

4.1. Diurnal variation in activities (*Hoolock hoolock)*

The captive Western Hoolock Gibbons were observed in order to analyze behavioural activities perform throughout the day. Gibbons spent the highest amount of time in resting (40.54%) than other activities in a day (Fig. 4.1).

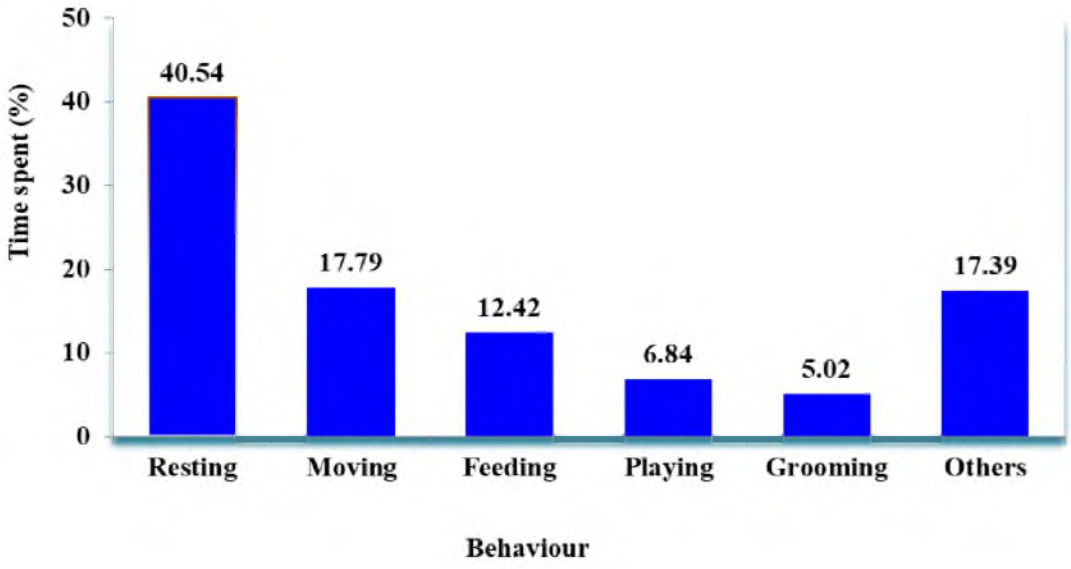


Fig. 4.1. Time spent in activities by Western Hoolock Gibbon in captivity.

4.1.1. Feeding activity

The Zoo authority provided different types of food (i.e.; cucumber, banana, orange, lemon, available seasonal fruits, bread and boiled eggs) (Appendix VIII) to Western Hoolock Gibbon in the morning (11am. to 12 pm). The highest time spent in feeding activities (51.88%) were recorded in the morning and the lowest (11.74%) in afternoon (Fig. 4.2). The time spent in feeding was significantly varied across the day ($F_{(2,33)}$=113.92, P=0.000, P<.05).

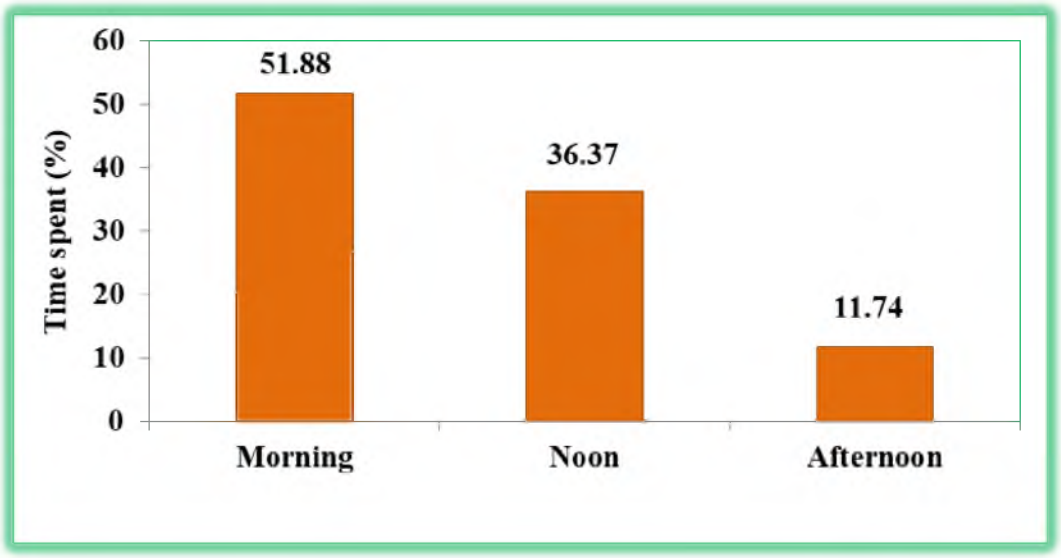


Fig. 4.2. Diurnal variation of feeding activity by Western Hoolock Gibbon in captivity.

4.1.2. Resting activity

Gibbon invested the highest amount of time in resting (72.89%) during afternoon (Fig. 4.3). There was significant differences in resting time across the day ($F_{(2,33)}$=485.71, P=0.000, P<.05).

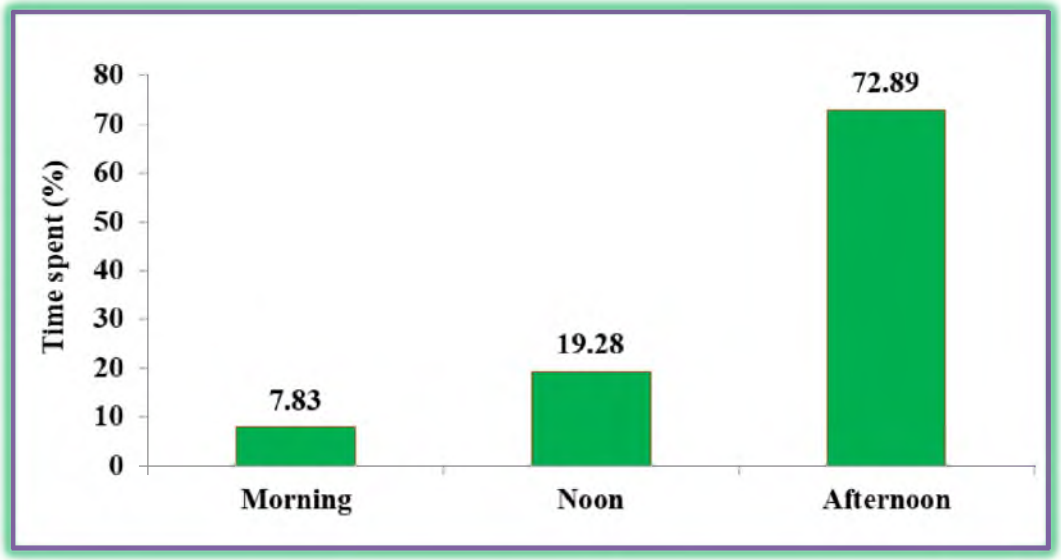


Fig. 4.3. Diurnal variation of resting time by captive Western Hoolock Gibbon.

Fig. 4.4. Feeding behaviour of Western Hoolock Gibbon.

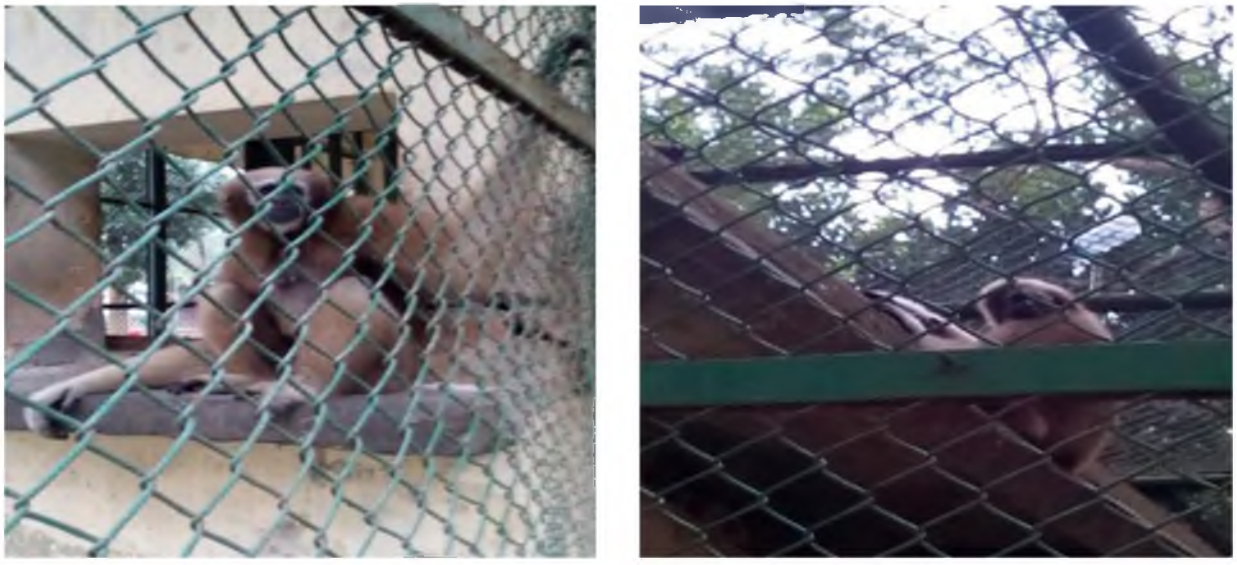


Fig. 4.5. Resting behaviour of Western Hoolock Gibbon.

4.1.3. Moving activity

The highest moving time (67.96%) was recorded in the morning than the other part of the day (Fig. 4.6). The moving activity was significantly varied in different parts of a day ($F_{(2,33)}$=126.864, P=0.000, P<.05). The correlation between resting and moving was significant and the relationship was negatively correlated ($r_{(34)}$=-0.566, P<0.01) (Appendix-XV).

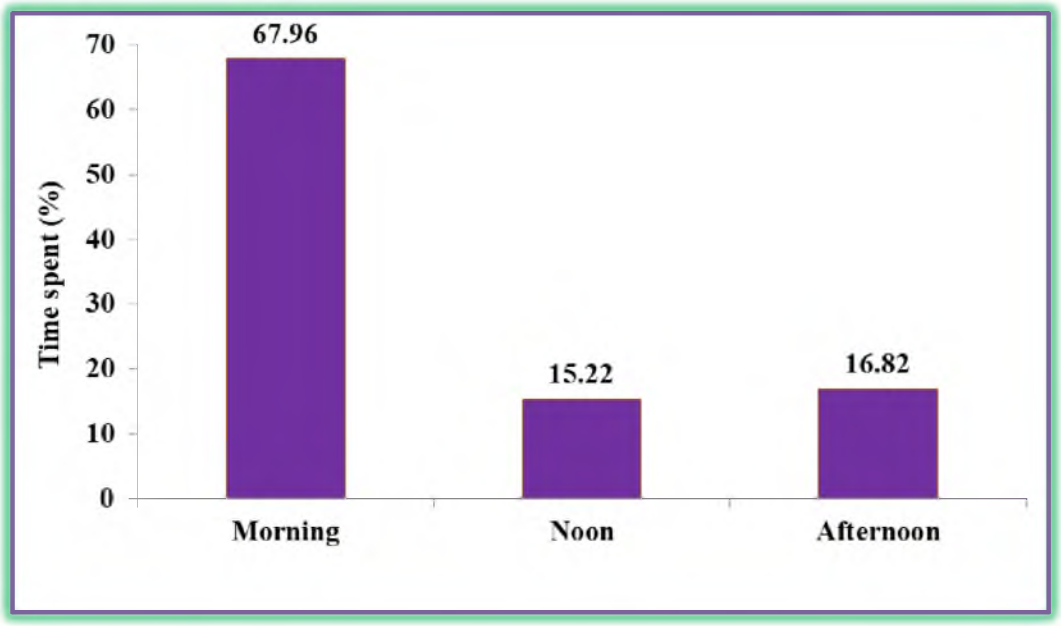


Fig. 4.6. Diurnal variation of moving time by captive Western Hoolock Gibbon.

4.1.4. Grooming activity

In captivity allogrooming was the highest (32.29%) during afternoon than the other part of the day (Fig. 4.7). But from the observation it was noted that the lowest auto-grooming was recorded in the morning (5.01%) (Fig. 4.7). It was found that there was significant differences between autogrooming and allogrooming in a day ($F_{(2,30)}$=21.341, P=0.000, P<.05).

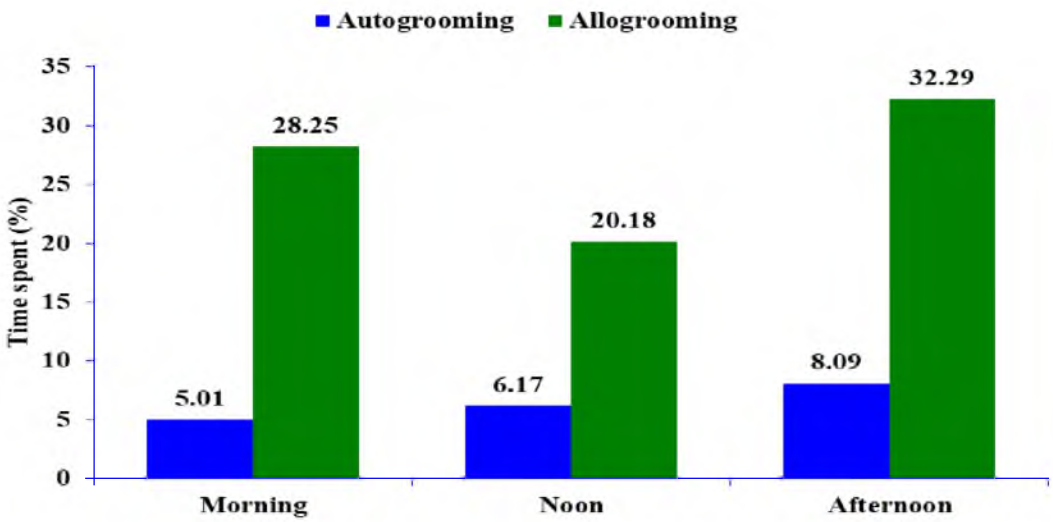


Fig. 4.7. Comparision between autogrooming and allogrooming of Western Hoolock Gibbon in captivity.

4.2. Diurnal variation in activities (sub adult *Hoolock hoolock)*

The sub adult Gibbon allotted the highest amount of time (57.96%) for feeding in the morning (Fig. 4.8). The resting was the most dominating behaviour in the afternoon (59.64%). They moved more in the morning (68.14%) than other parts of the day. On the other hand, the grooming time was the highest in the afternoon (45.21%) (Fig. 4.6).

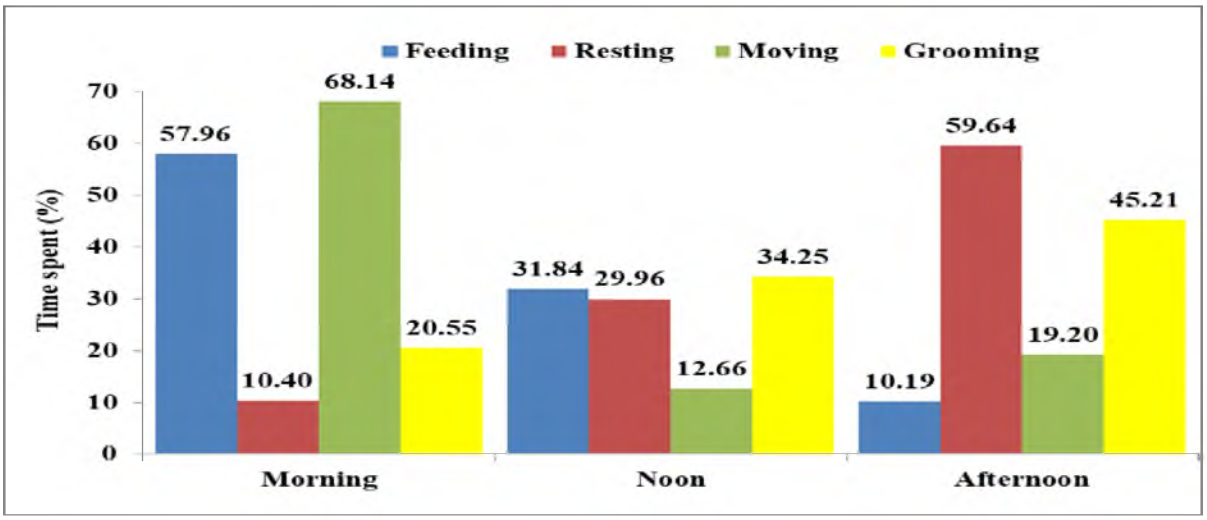


Fig. 4.8. Diurnal variation of activities of sub adult Gibbon.

Fig. 4.9. Moving behaviour of Western Hoolock Gibbon.

Fig. 4.10. Grooming behaviour of Western Hoolock Gibbon.

4.3. Age class differences of activity pattern of Hoolock Gibbon in captivity

Behavioral activities always vary in different age classes. The sub adult and the adult showed variations in the time spent in different activities such as feeding, resting, moving and grooming behviour throughout the day.

During morning the highest feeding time was spent in case of both age classes. The sub adult female utilized more time in feeding (57.96%) than the adult female (46.25%) in the morning (Fig. 4.11). The feeding time spent between two age classes was not significantly varied T-test $T_{(22)}$=-0.028, P=0.978, P>.05 (Appendix-IX).

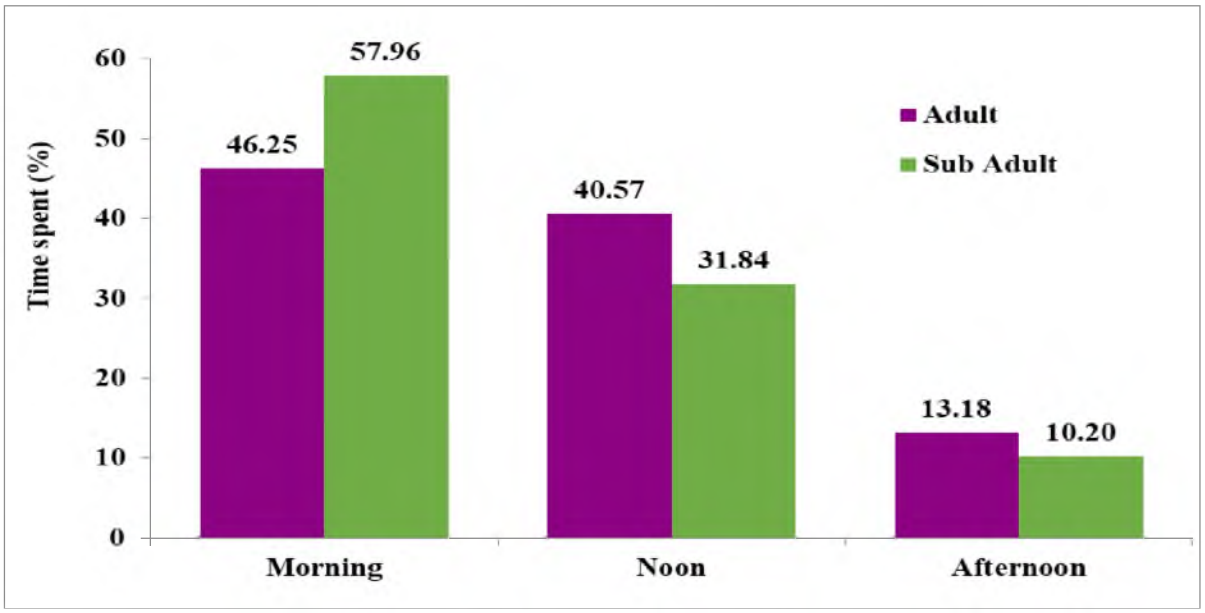


Fig. 4.11. Differences of feeding time between the adult and the sub adult Gibbon.

The resting time in case of both age classes was the highest in the afternoon (Fig 4.12). During this time period, the adult female Gibbon spent more time in resting than the sub-adult. But at noon the sub adult Gibbon spent more time in resting than the adult (Fig. 4.12). The mean time spent in resting was not significantly varied (T-test $T_{(22)}$=1.329, P=0.198, P>.05).

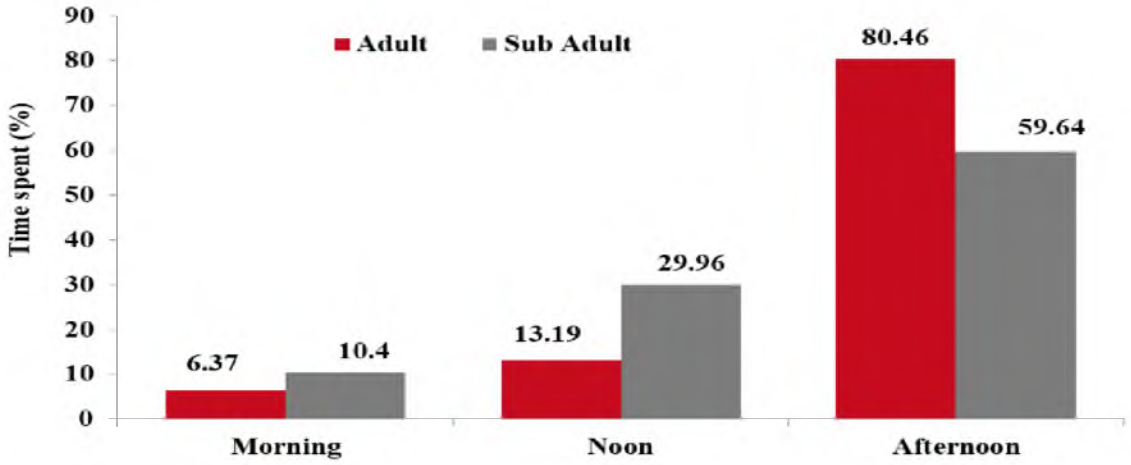


Fig. 4.12. Variation of resting time between the adult and the sub adult Gibbon.

The moving time was also fluctuated in two age classes of Gibbons. The moving time was the highest during morning and the sub adult spent more time than the adult in the morning (68.14%) and afternoon (19.20%) (Fig. 4.13). But the time spent moving across the day was not significant (T-test $T_{(22)}$=-0.609, P=0.549, P>.05) (Appendix-X).

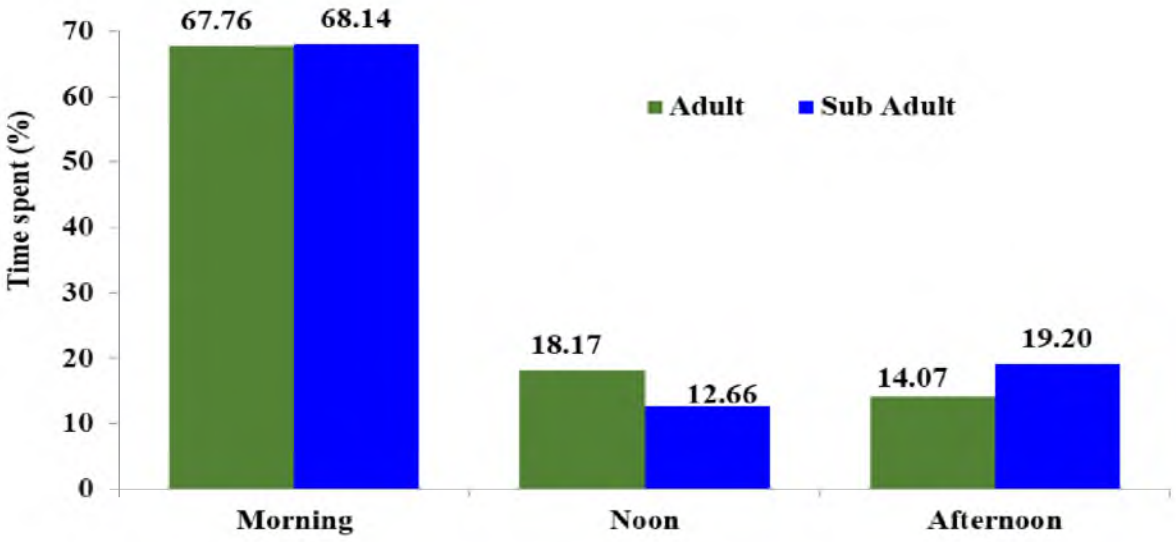


Fig 4.13. Variation of moving time between the adult and the sub adult Gibbon.

In most of the time the grooming activities was high in case of the sub-adult throughout the day and it was significantly varied ($T_{(22)}$=5.071, P<.05) and the highest time spent in grooming by the adult Gibbon was recorded during afternoon (60.14%) than the other parts of the day (Fig. 4.14).

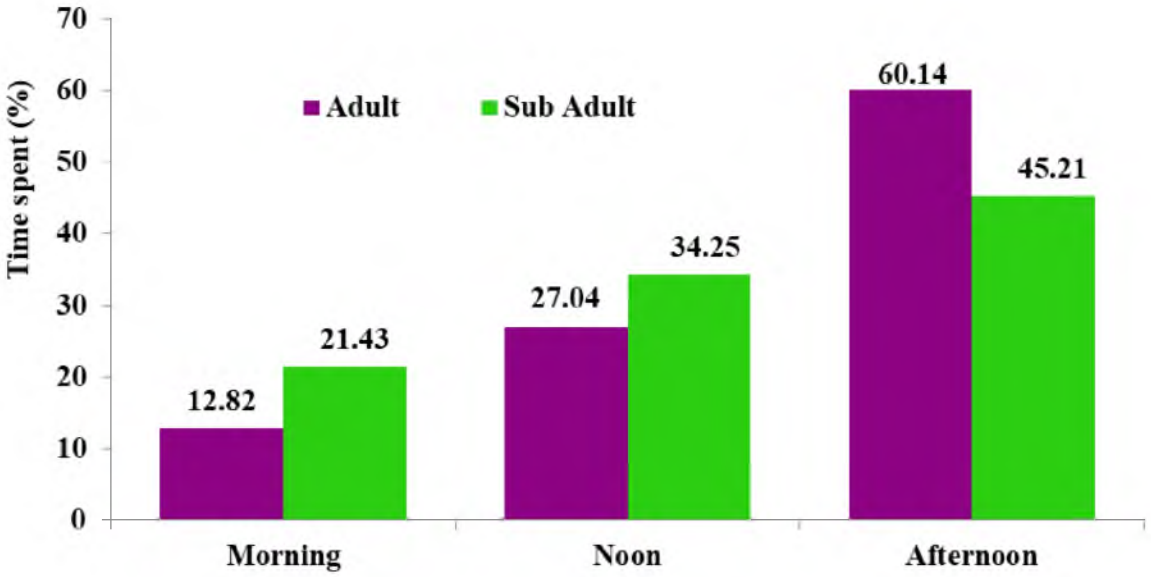


Fig. 4.14. Variation of grooming time between the adult and the sub adult Gibbon.

4.4. Monthly variation in activities (*Hoolock hoolock)*

Gibbons spent the highest amount of time in feeding (31.50%) in the month of May and the lowest in January (20.30%) (Fig. 4.15).

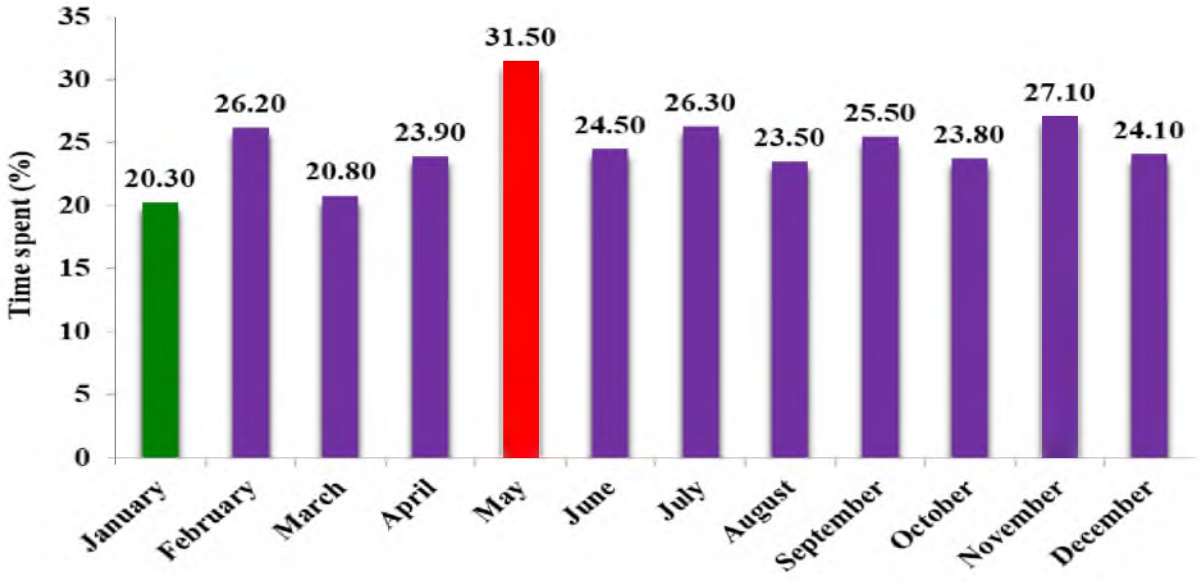


Fig. 4.15. Monthly variation in feeding by captive Western Hoolock Gibbon.

They spent maximum amount of time (31.80%) in resting in August and the lowest (18.30%) in the month of May (Fig. 4.16).

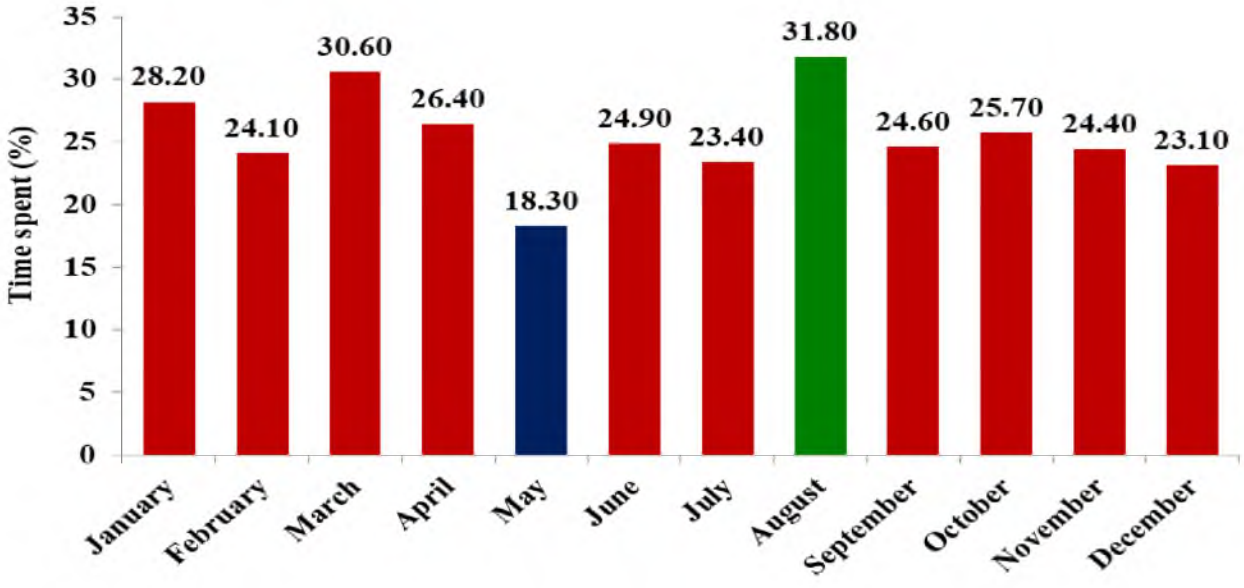


Fig. 4.16. Monthly variation in resting by captive Western Hoolock Gibbon.

During this study the highest moving (29.50%) was recorded in the month of April than the other months of the year and the lowest in August (21.20%) (Fig. 4.17).

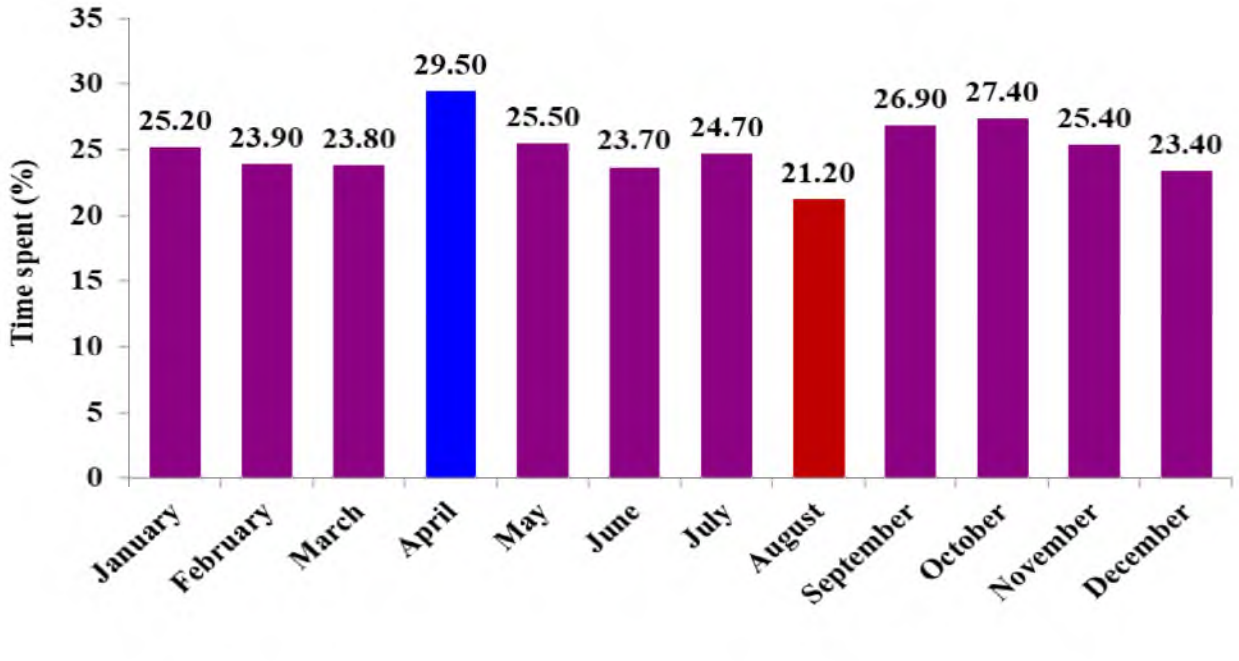


Fig. 4.17. Monthly variation in moving by captive Western Hoolock Gibbon.

The grooming was the highest in December (29.40%) and the lowest in April (20.20%) (Fig. 4.18).

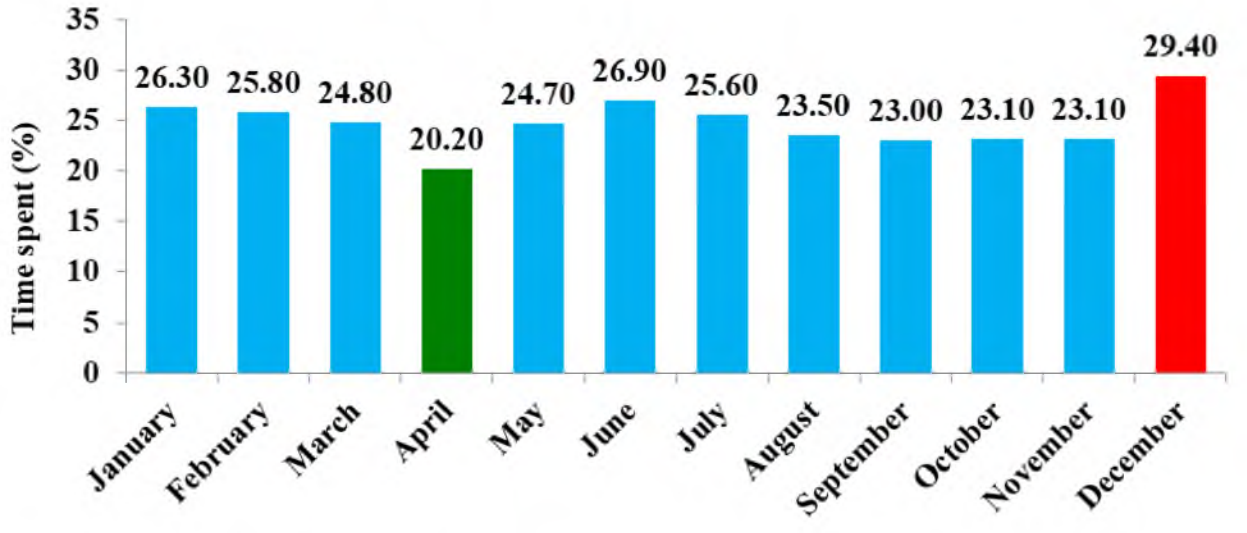


Fig. 4.18. Monthly variation in grooming by captive Western Hoolock Gibbon.

4.5. Seasonal variation in activities (*Hoolock hoolock)*

The resting time was the highest during rainy season (38.03%) than the other parts of the year. Feeding time was the highest during summer (38.32%). The highest moving time (37.66%) was also recorded in summer. The time spent in grooming was the highest during winter (43.13%) (Fig. 4.19).

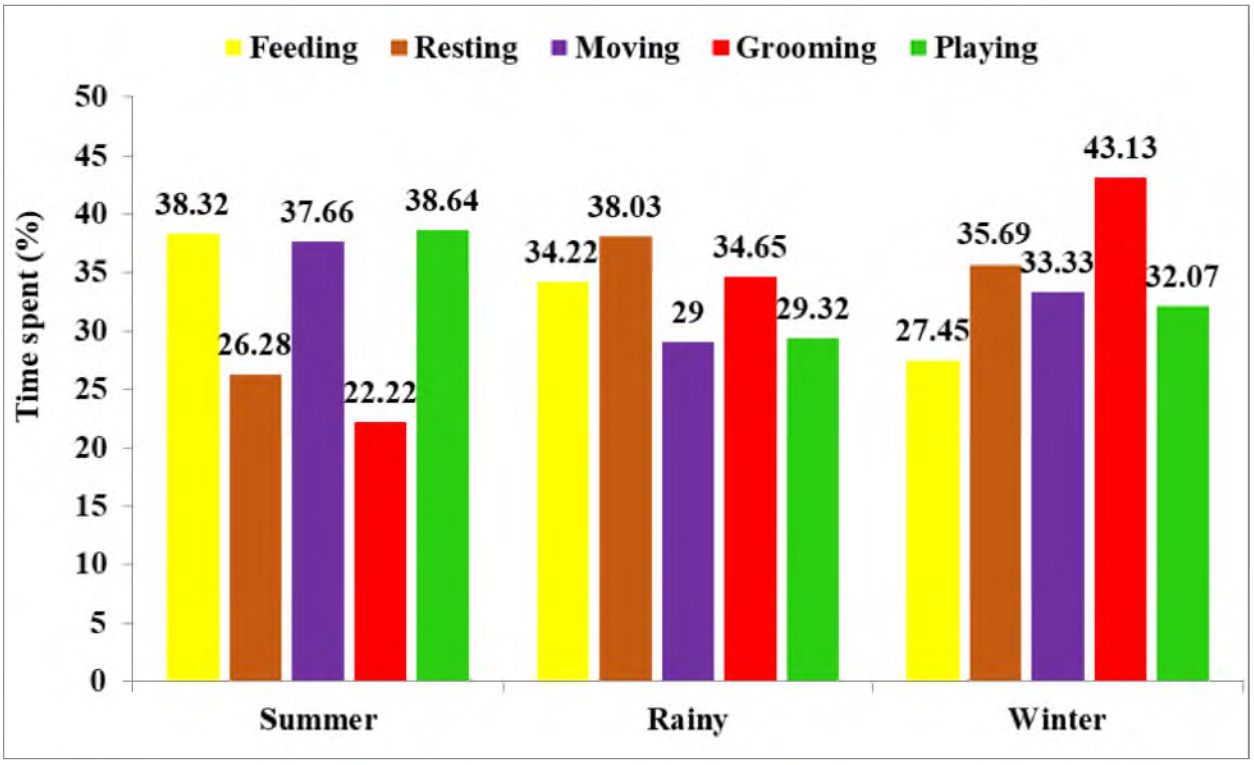


Fig. 4.19. Seasonal variation of activities of Western Hoolock Gibbon.

Seasonality of behavioural activities

Feeding

The time spent feeding was significantly varied across the seasons ($F_{(2,33)}$=118.527, P=0.000, P<.05). Fig. 4.20 showed to what extent the feeding behaviour deviated from the average seasonal record. The time spent feeding was more than the average seasonal feeding time spent during summer and it was less during winter.

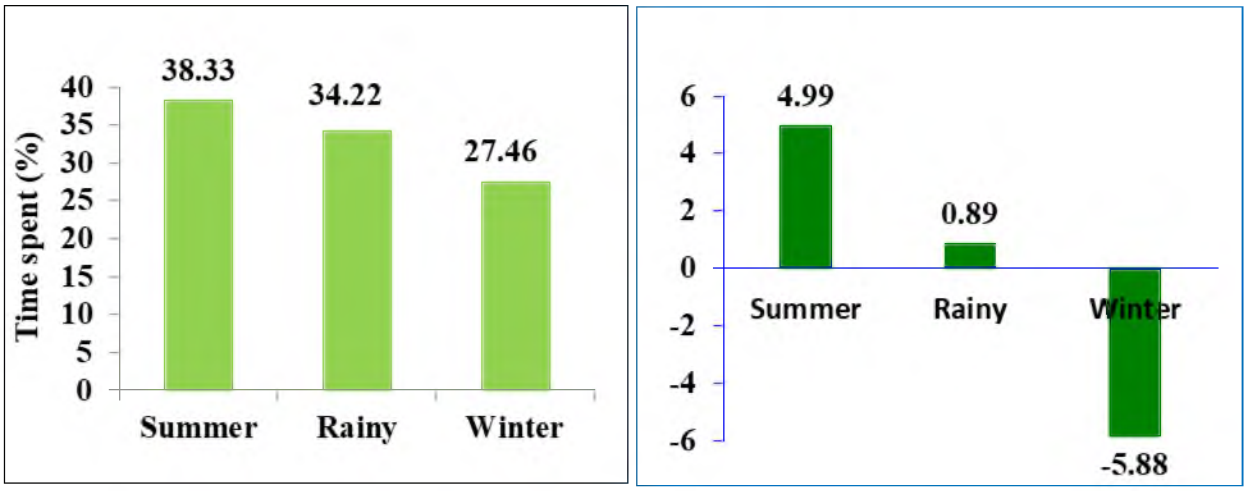


Fig. 4.20. Seasonal deviation in feeding activity pattern of Western Hoolock Gibbon.

Resting

The time spent resting was varied significantly across the seasons ($F_{(2,33)}$=87.203, P=0.000, P<.05). A positive diversion was noticed in resting during rainy season than the average seasonal resting record. Gibbon spent more time in resting during rainy season than the time spent resting in other seeasons (Fig. 4.21).

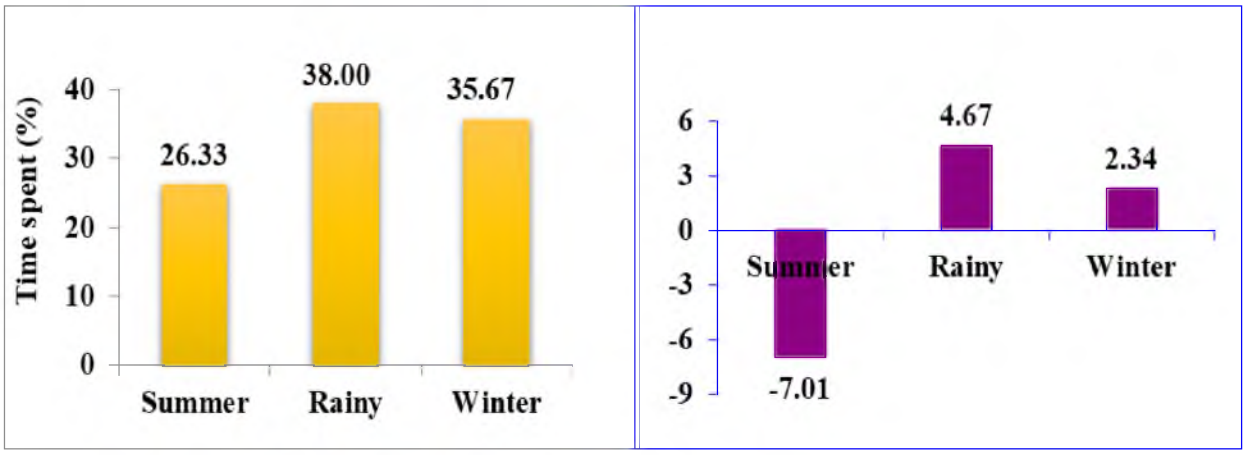


Fig. 4.21. Seasonal deviation in resting activity of Western Hoolock Gibbon.

Moving

The moving time spent was significantly varied across the seasons ($F_{(2,33)}$=73.360, P=0.000, P<.05). There was no moving deviation in winter season (Fig.4.22).Gibbons spent more time in moving in summer while the highest negative deviation was recorded during rainy season.

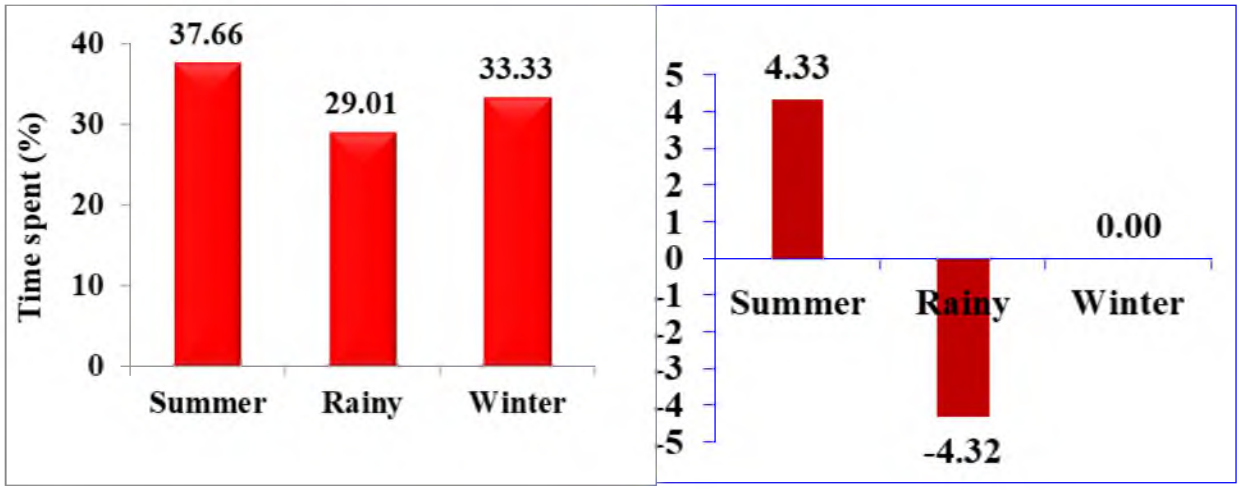


Fig. 4.22. Seasonal variation in moving activity of Western Hoolock Gibbon.

Grooming

There was significant differences in grooming time spent across the seasons ($F_{(2,33)}$=271.859, P<.05). Fig.4.23. showing that the grooming record was negatively deviated from the average value while the winter was the most dominnant season acorss the three seasons.

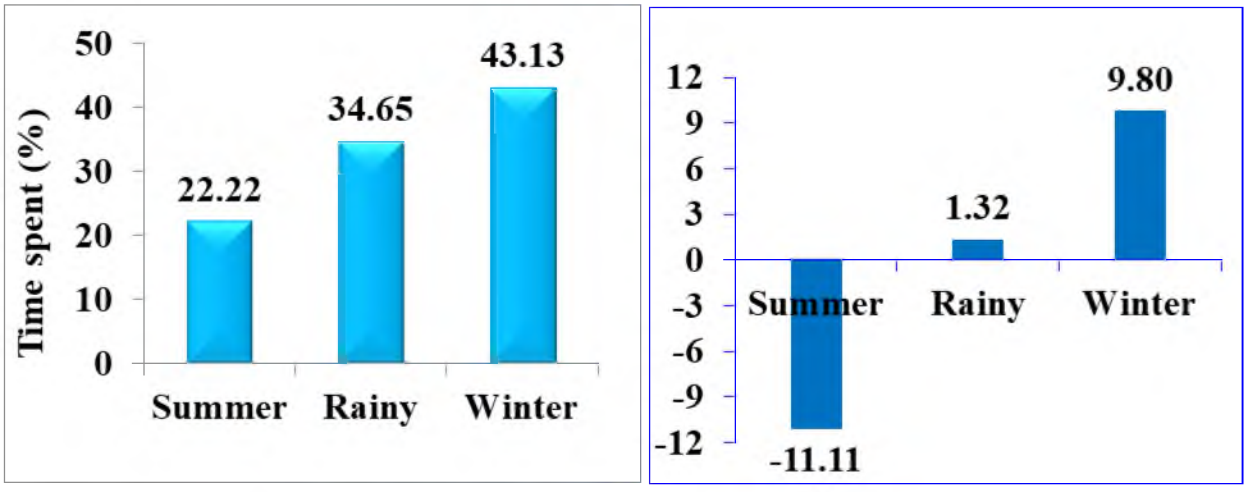


Fig. 4.23. Seasonal variation in grooming activity of Western Hoolock Gibbon.

4.6. Temperature affects the behavioural activities (Hoolock Gibbon)

During the observation period the temperature varied from 14°C to 34°C. The Hoolock Gibbon spent the highest amount of time in feeding (31.5%) when the highest temperature was 29°C. There was no significant difference in time spent of feeding when the temperature ranged between 14°-33°C. The highest resting (31.8%) was recorded when the average temperature was 29.5°C. The highest amount of time (29.5%) was spent in moving when the average temperature was 28.5°C. The highest grooming time (29.4%) was recorded when the average temperature was 20.5°C(Fig. 4.24).

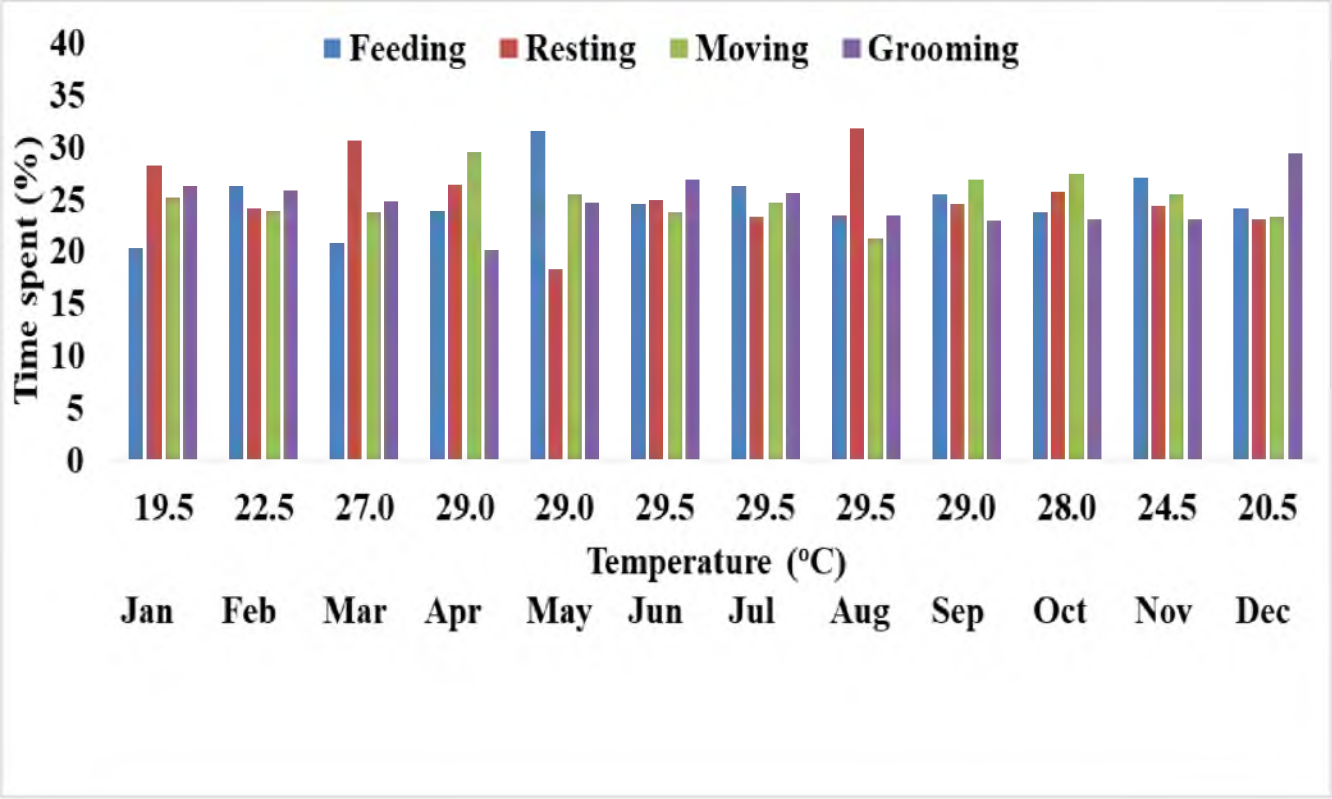


Fig.4.24. Percentage of different behavior of captive Gibbon based on temperature.

4.7. Effect of visitor's presence on behavioural activities

During the study period it was observedthat the resting time gradually decreased with the increasing number of the visitors (Fig. 4.25). The percentage of moving tended to rise when the number of visitors was more than 20 persons. Similarly the percentage of hawling rose from 15.15% to 54.26% when the visitors number increased (>20 persons).

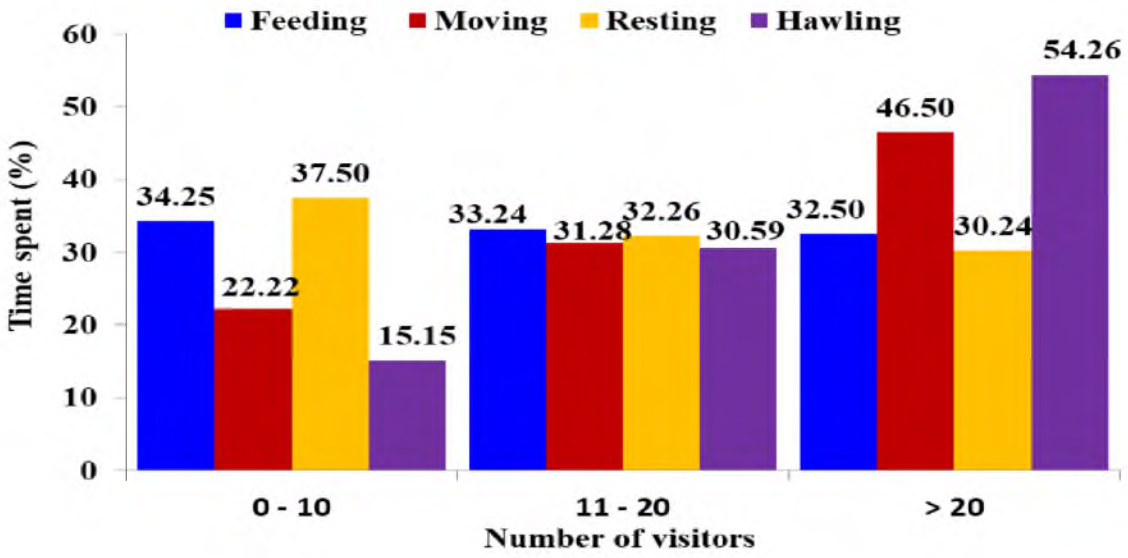


Fig.4.25. Effect of presence of visitors on the behaviour of captive Gibbon.

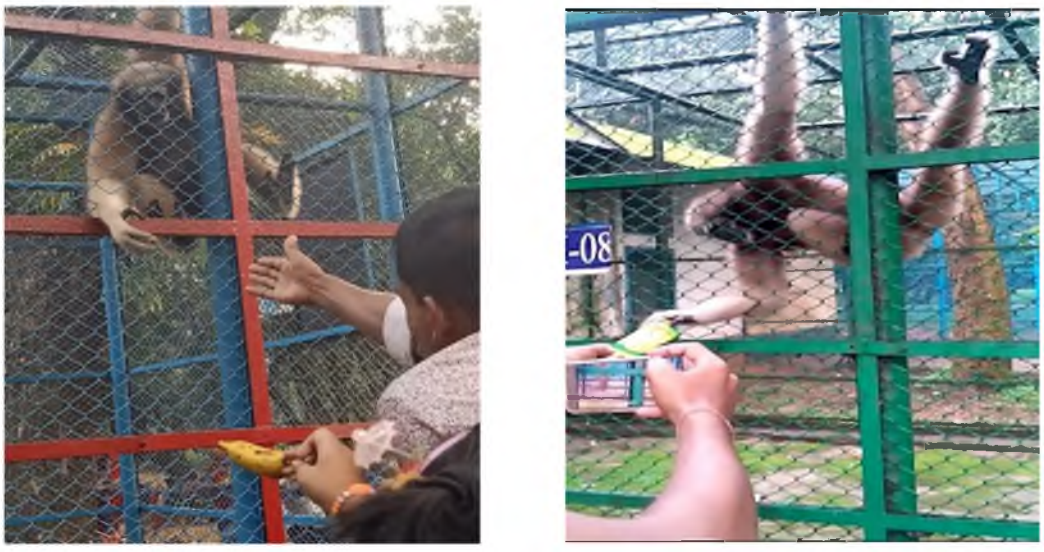


Fig. 4.26. Interaction of Hoolock Gibbon with visitors.

4.8. Diurnal variation in activities (*Ursus thibetanus)*

Asiatic Black Bears in Bangladesh National Zoo exhibited variation in different behaviours throughout the day like the other captive species. However, it was recorded that the studied bear spent the highest amount of time in resting (55.63%), followed by feeding (16.50%) moving (11.55%) grooming (3.42%) and other activities (12.90%) (Fig. 4.27).

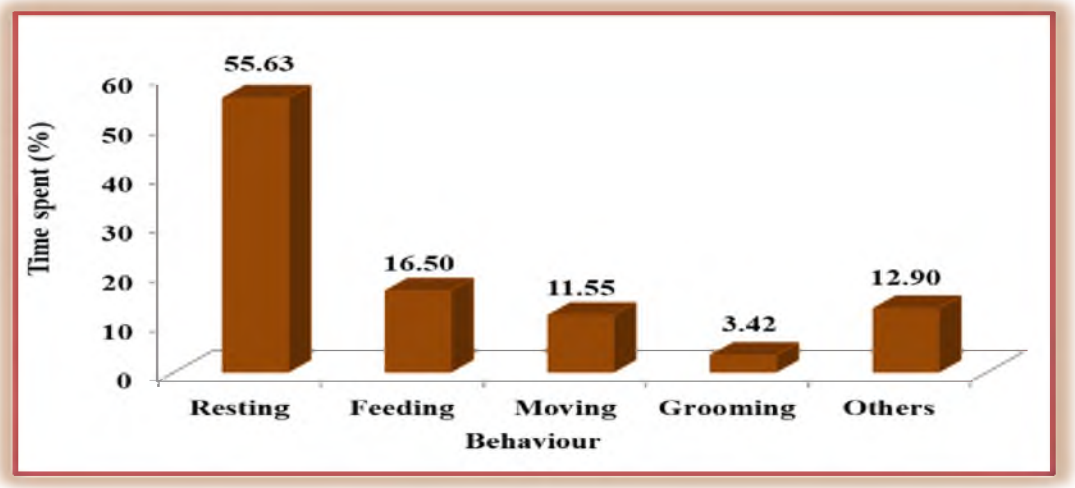


Fig. 4.27. Percentages of time spent in activities by Asiatic Black Bear in activity.

4.8.1. Feeding activity

Captive bear showed the highest time spent in food intake (86.91%) in the noon than other part of the day (Fig. 4.28). The time spent feeding was significantly varied across the day ($F_{(2,33)}$ = 8207.448, P<.05) (Appendix-XI).

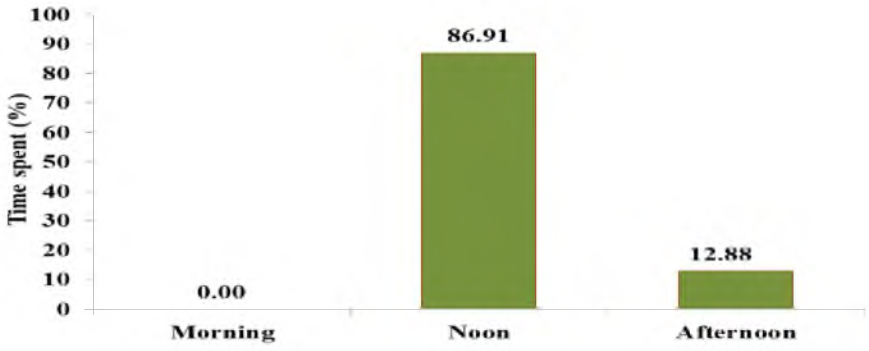


Fig. 4.28. Diurnal variation in feeding activity of captive Asiatic Black Bear.

Fig. 4.29. Feeding behaviour of captive Asiatic Black Bear.

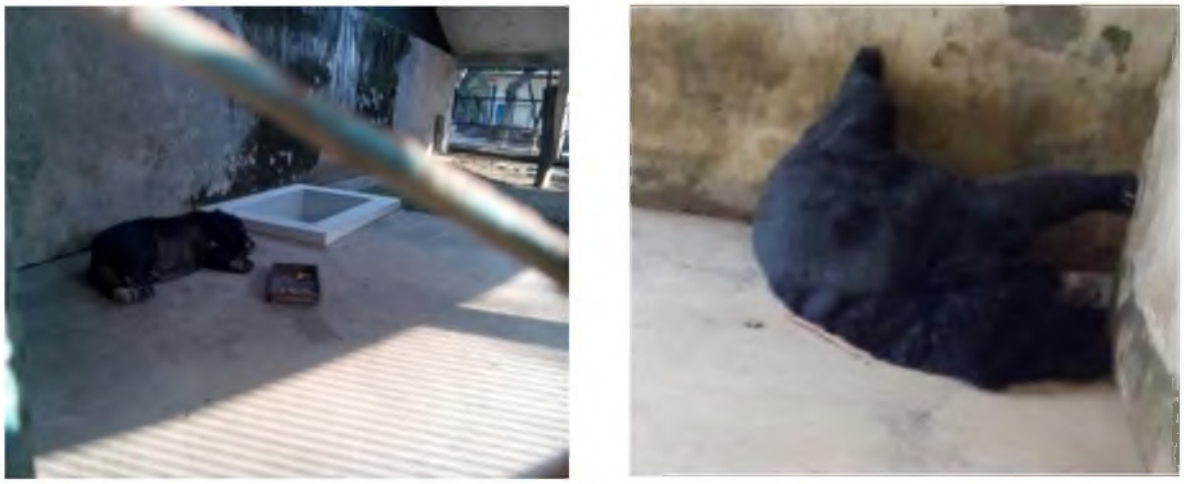


Fig. 4.30. Resting behaviour of captive Asiatic Black Bear.

Fig. 4.31. Moving behaviour of captive Asiatic Black Bear.

4.8.2. Resting activity

In the morning, captive Bears were observed to spend the lowest time in resting (13.42%). In contrast during afternoon the highest time spent in resting (62.74%) was noted down (Fig. 4.32). There was a significant differences in resting time spent in a day ($F_{(2,33)}$=1127.439, P<.05) (Appendix-XII).

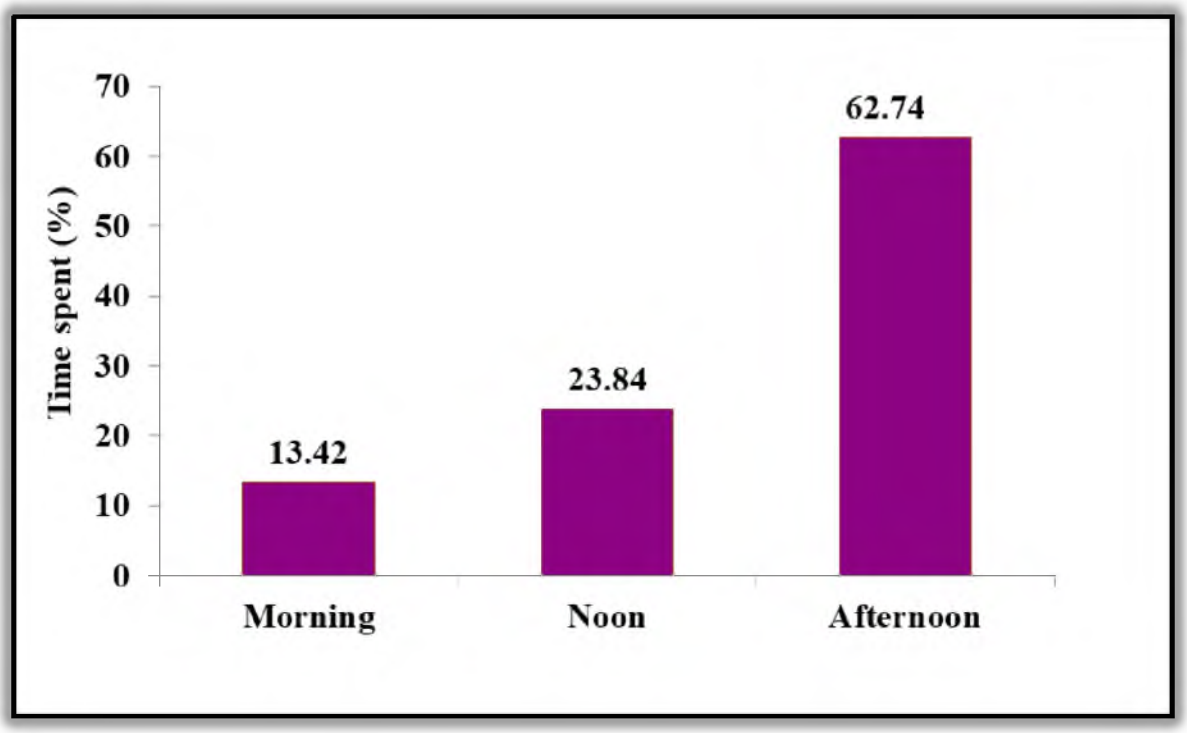


Fig. 4.32. Diurnal variation in resting activity of captive Asiatic Black Bear.

4.8.3. Moving activity

During morning the captive Black Bear moved more (49.08%) than other time period of a day. Whereas, the lowest (11.95%) time spent was recorded during afternoon (Fig. 4.33). The moving time spent was significantly varied during three different parts of a day ($F_{(2,33)}$=729.379, P<.05). There was strong negative relationship between resting and moving ($r_{(34)}$=-0.976, P<0.01) (Appendix-XVI).

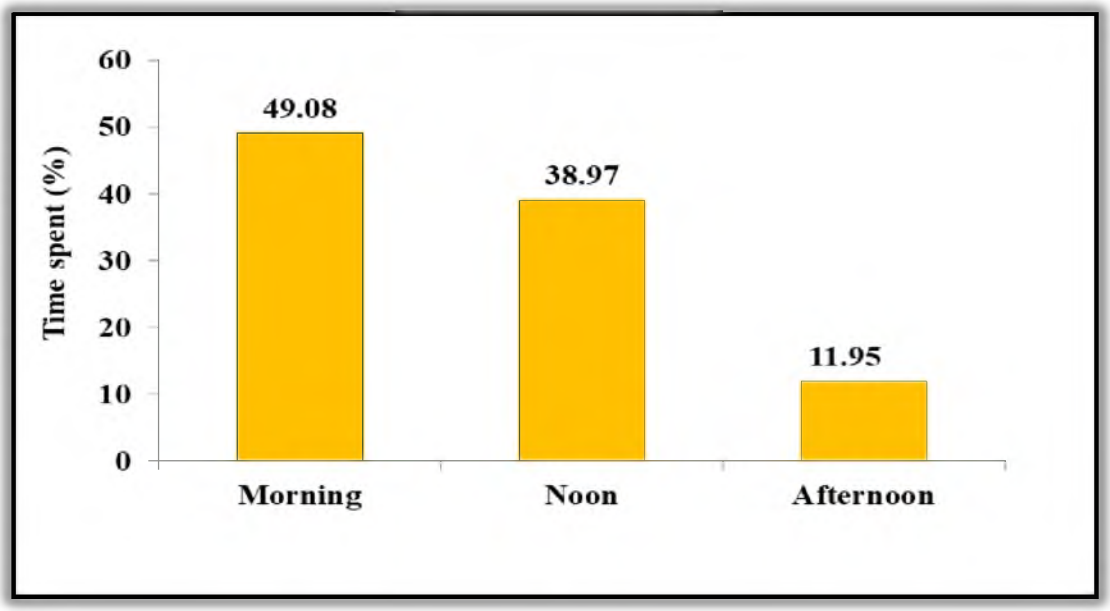


Fig. 4.33. Diurnal variation in moving activity of captive Asiatic Black Bear.

4.9. Monthly variation in activities (*Ursus thibetanus)*

Asiatic Black Bear of the studied group spent the highest time in feeding (31.00%) in the month of December and the lowest (17.30%) in May (Fig. 4.34).

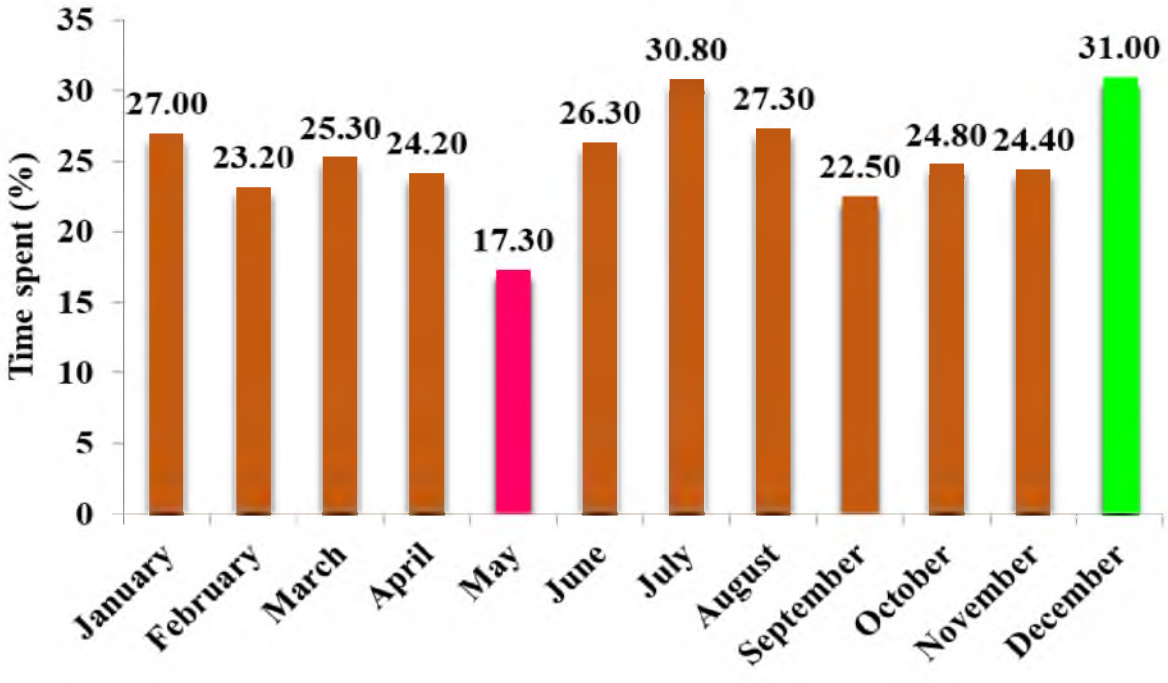


Fig. 4.34. Monthly variation in feeding activity of captive Asiatic Black Bear.

Asiatic Black Bear was found to spend the maximum amount of time in resting (29.50%) in the month of December and spent the minimum amount of time in May (19.30) (Fig. 4.35).

Fig. 4.35. Monthly variation in resting activity of captive Asiatic Black Bear.

The captive Asiatic Black Bear increased the moving activity (34.50%) in the month of May. On the other hand, the lowest time spent moving (22.40%) was recorded in the month of December (Fig. 4.36).

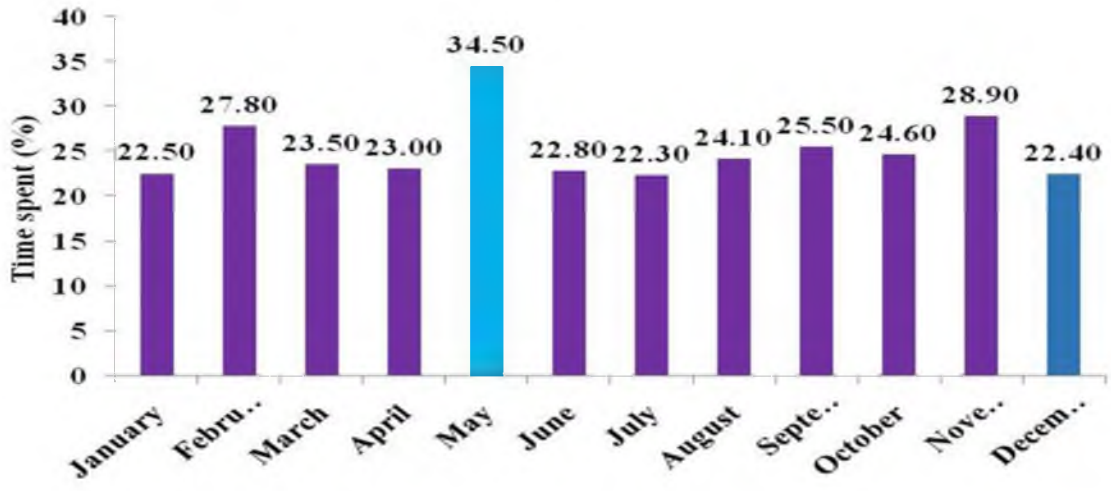


Fig. 4.36. Monthly variation in moving of captive Asiatic Black Bear.

The Asiatic Black Bear utilized the highest amount of time in grooming (29.20%) in the month of April. In contrast the lowest amount of time was spent in the month of July (17.00%) (Fig. 4.37).

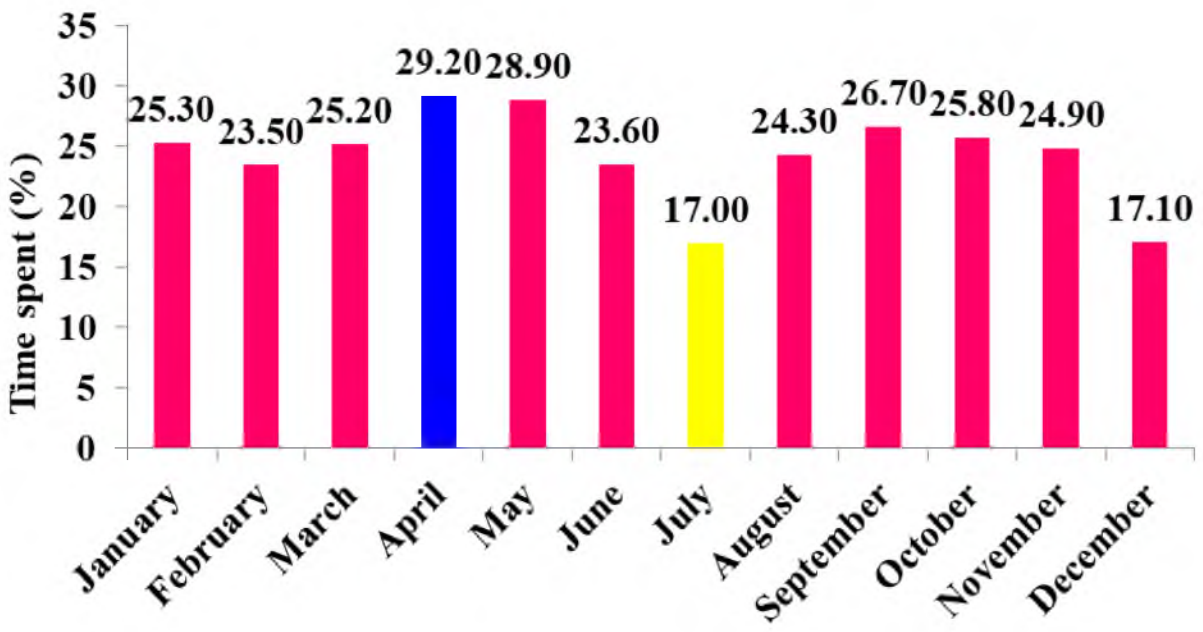


Fig. 4.37. Monthly variation in grooming of captive Asiatic Black Bear.

4.10. Seasonal variation in activities (*Ursus thibetanus)*

Bears were found to invest the highest amount of time in resting (37.34%) and feeding (38.33%) during winter season, and the lowest time was during summer. The highest moving was recorded (38.00%) during summer when the lowest in rainy season (28.66%). The time spent of grooming was the highest in summer and the lowest was during rainy season (Fig.4.38).

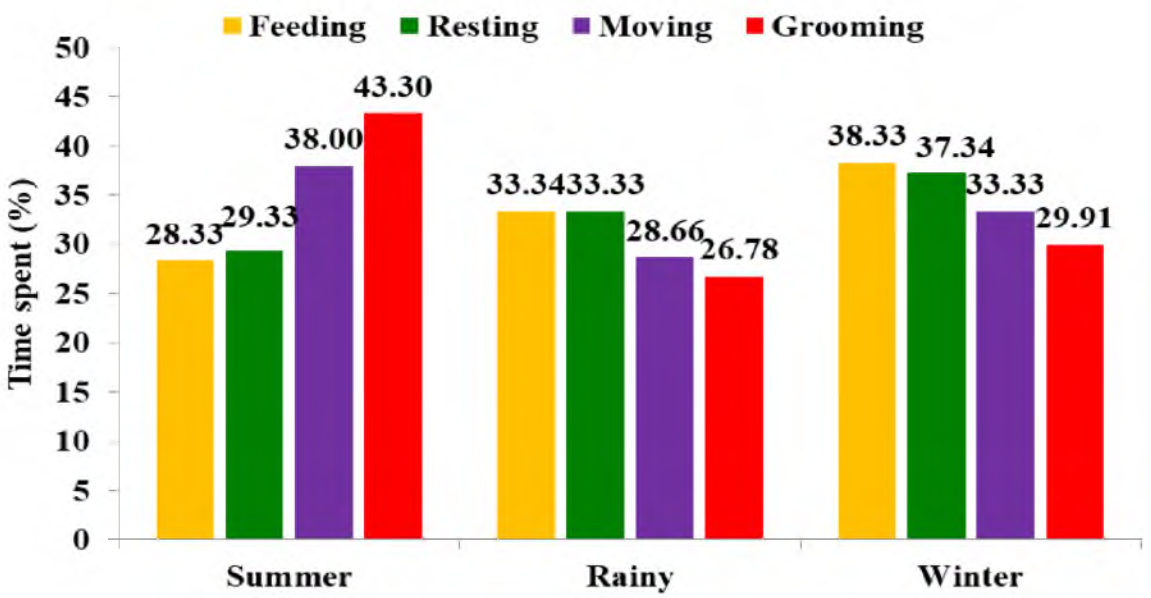


Fig. 4. 38. Seasonal variation of activities of captive Asiatic Black Bear.

Seasonality of behavioural activities

Feeding

The moving time spent was significantly varied across the seasons ($F_{(2,15)}$=32.983, P<.05. The deviation average record in feeding during rainy season was hardly noticeable while it was positive (highest) during winter and negative (lowest) during summer season (Fig. 4.39).

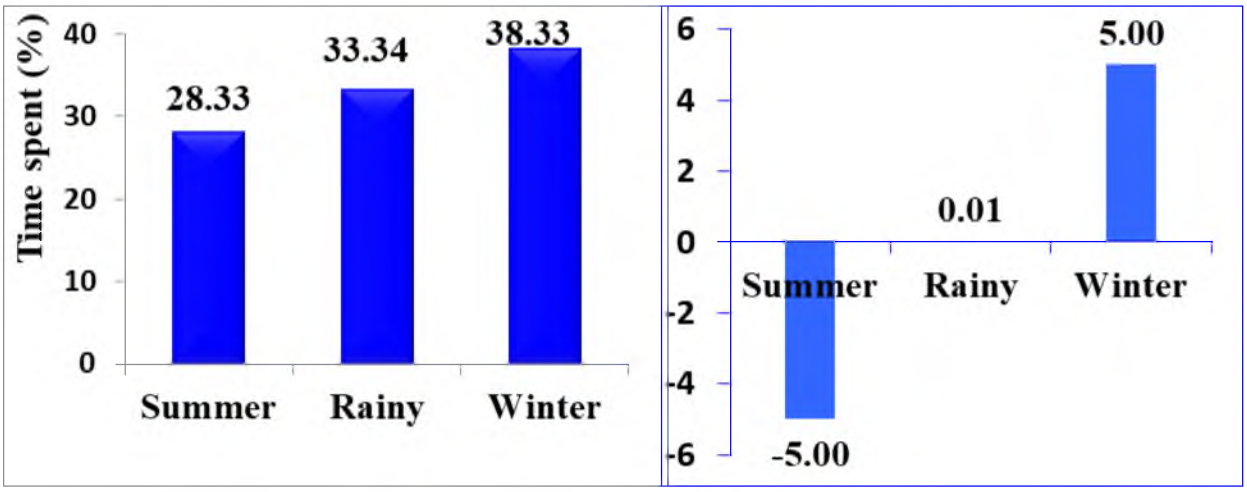


Fig. 4.39. Seasonal variation of feeding activity of Asiatic Black Bear.

Resting

There was significant difference in time spent resting across the seasons. Where, $F_{(2,15)}$=12.338, P=0.001, P<.05. Captive bears were noticed to spend more time in winter and less time in summer than the average record in resting behavior (Fig. 4.40).

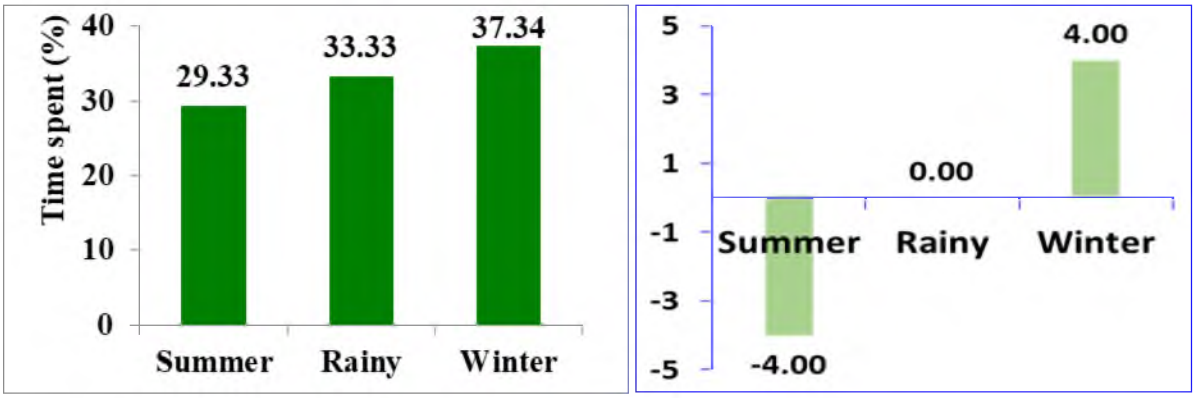


Fig. 4.40. Seasonal variation of resting activity of captive Asiatic Black Bear.

Moving

The time spent moving varied significantly across the seasons ($F_{(2,15)}$=11.37, P=0.001, P<.05) (Appendix-XIV). No deviation was noted in moving during winter while the deviance was positive during summer. However, negative diversion was noticeable during rainy season (Fig. 4.41).

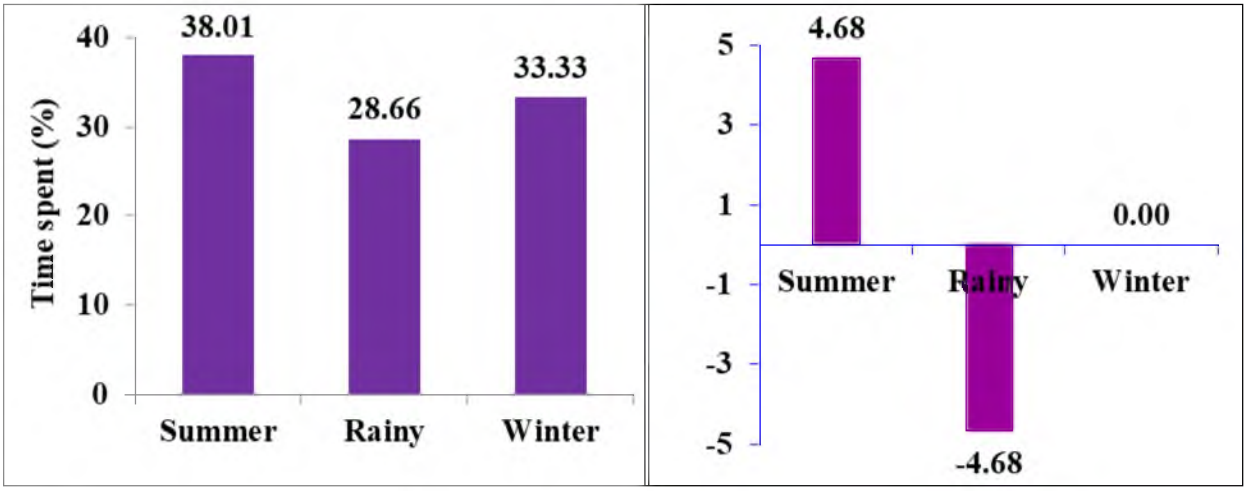


Fig. 4.41. Seasonal variation of moving activity of captive Asiatic Black Bear.

Grooming

The mean time spent in grooming was significantly varied among the three seasons ($F_{(2,15)}$=40.223, P<.05). During rainy and winter seasons bears showed negative time spent and a positive time spent was recorded during summer (Fig. 4.42).

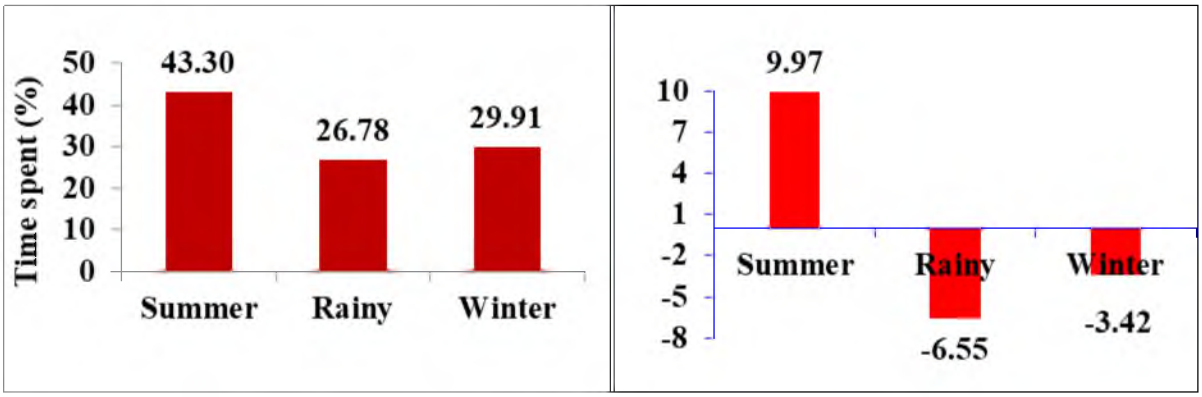


Fig. 4.42. Seasonal variation of grooming activity pattern of captive Asiatic Black Bear.

4.11. Temperature affects the behavioural activities (*Ursus thibetanus*)

When the temperature was 20.5^{0}C the Asiatic Black Bear showed the highest time spent in feeding (31.00%) and in 29^{0}C the lowest feeding (17.30%) was recorded. The highest amount of time was invested in resting (29.50%) when the average temperature was 20.5^{0}C. The maximum (34.50%) moving was occurred when the average temperature was 29^{0}C. The time spent in grooming was the highest (29.20%) when the average temperature was 29^{0}C (Fig. 4.43).

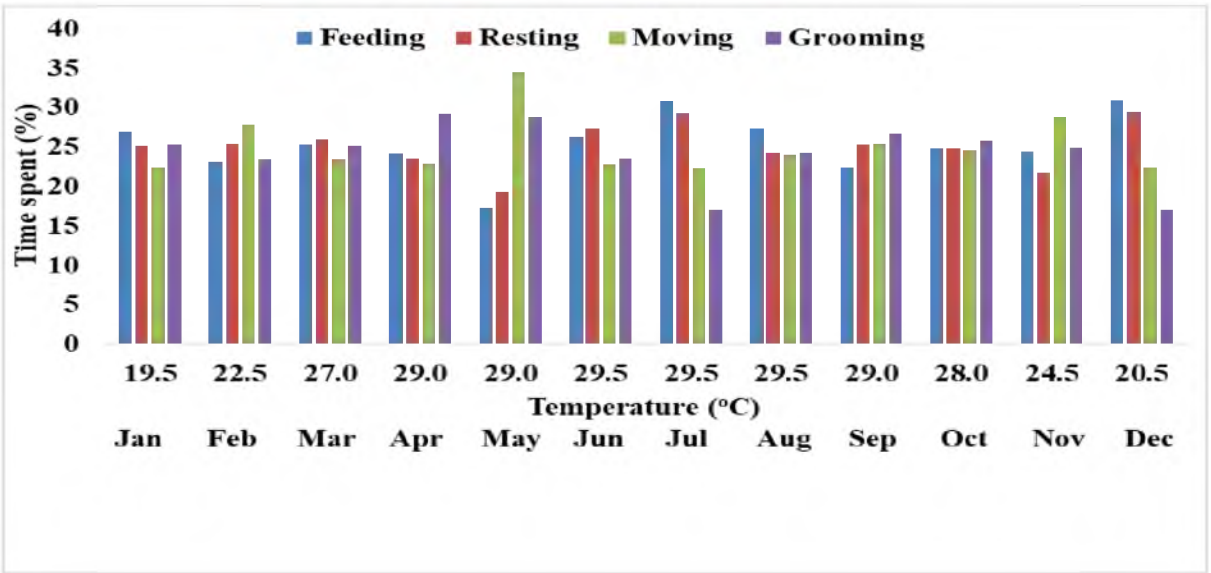


Fig. 4.43. Percentage of different behaviour of captive Bear based on temperature.

4.12. Diurnal variation in activities (*Canis aureus*)

Asiatic Jackal spent the highest amount of time in moving (29.29%) followed by resting and feeding. Time spent on resting was 15.43% and feeding was 12.52% (Fig. 4.44). There was significant difference in time spent on various activities in a day ($F_{(2,42)}$=1209.009, P<.05).

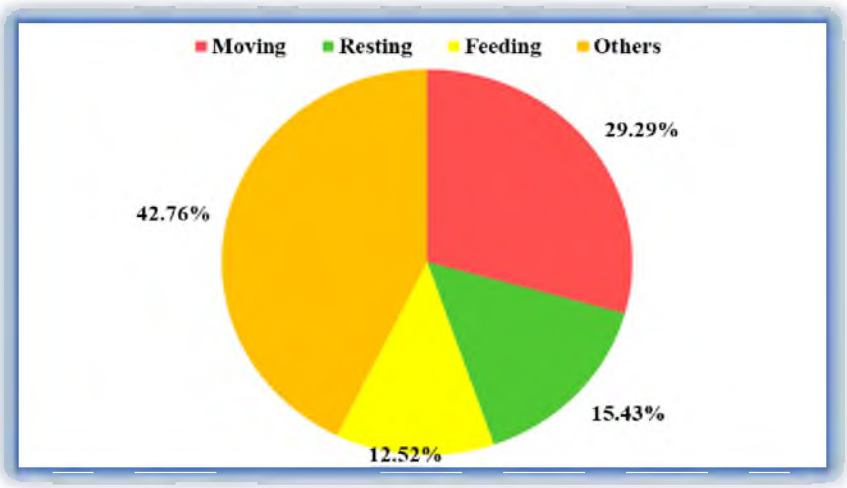


Fig. 4.44. Time spent in activities by captive Asiatic Jackal.

4.13. Monthly variation in feeding (Asiatic Jackal)

Asiatic Jackal increased the feeding activity in the month of January (26.75%), while the lowest time spent was observed in May (23.25%) (Fig.4.45). Feeding was significantly varied across the months ($F_{(1,22)}$=214.101, P<.05).

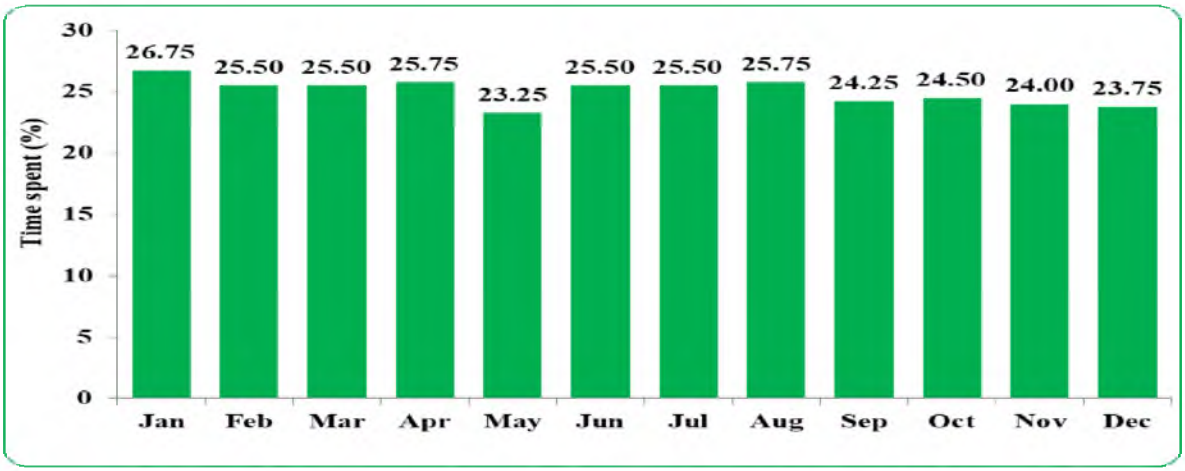


Fig. 4.45. Monthly variation in feeding activity of captive Asiatic Jackal.

Monthly variation in resting of Asiatic Jackal

The time spent in resting was the highest in December (26.50%) while the lowest observed value was in the month of September 23.25% (Fig.4.46). Time spent in resting across the months was significant ($F_{(1,22)}$=291.229, P<.05).

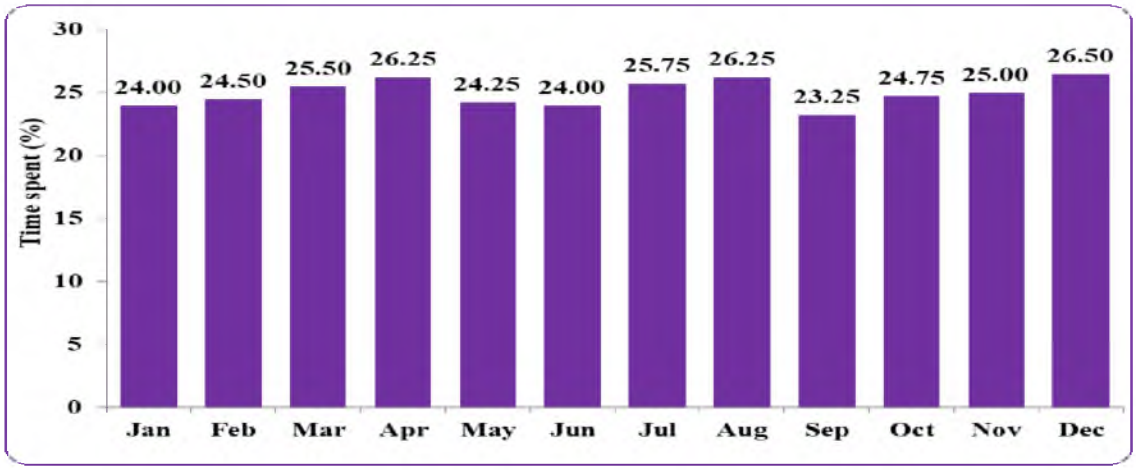


Fig. 4.46. Monthly variation in resting of captive Asiatic Jackal.

Monthly variation in moving of Asiatic Jackal

Captive Asiatic Jackal invested the maximum time in moving in the month of August (26.00%) and the minimum time spent in January (22.75%) (Fig. 4.47). Monthly variation in moving of Asiatic Jackal was significantly varied ($F_{(1,22)}$=287.348, P<.05).

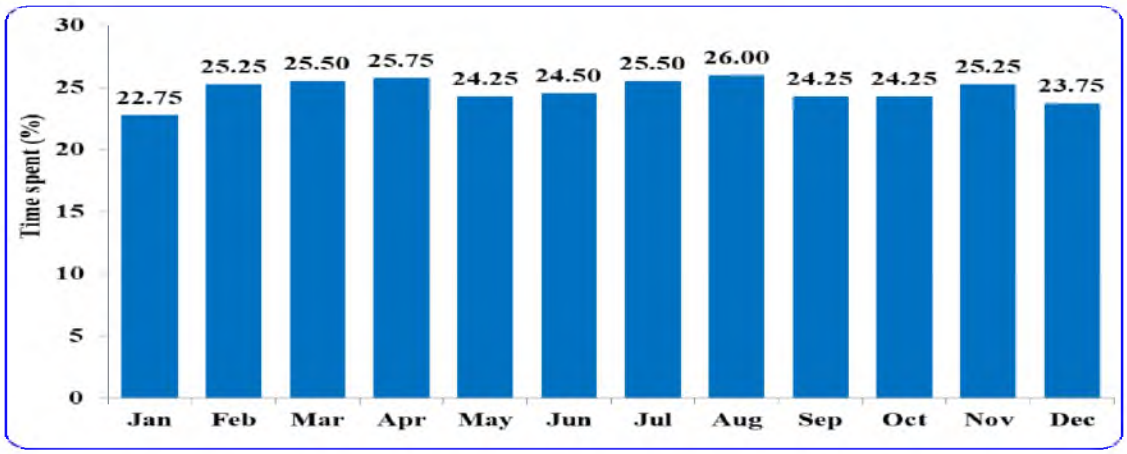


Fig. 4.47. Monthly variation in moving of captive Asiatic Jackal.

Fig. 4.48. Asiatic Jackal (*Canis aureus*) housed in tiny enclosures.

4.14. Seasonal variation in activities (*Canis aureus*)

The highest feeding (36.32%) time was reported during winter season while the lowest was in the summer (30.34%) (Fig.4.40). Jackals utilized the highest amount of time in resting (37.33%) during winter season. Whereas, the minimum time was spent (29.34%) in resting during rainy season. Time spent for moving was the highest during rainy season (38.33%) and the lowest was during winter season (28.33%) (Fig. 4.49).

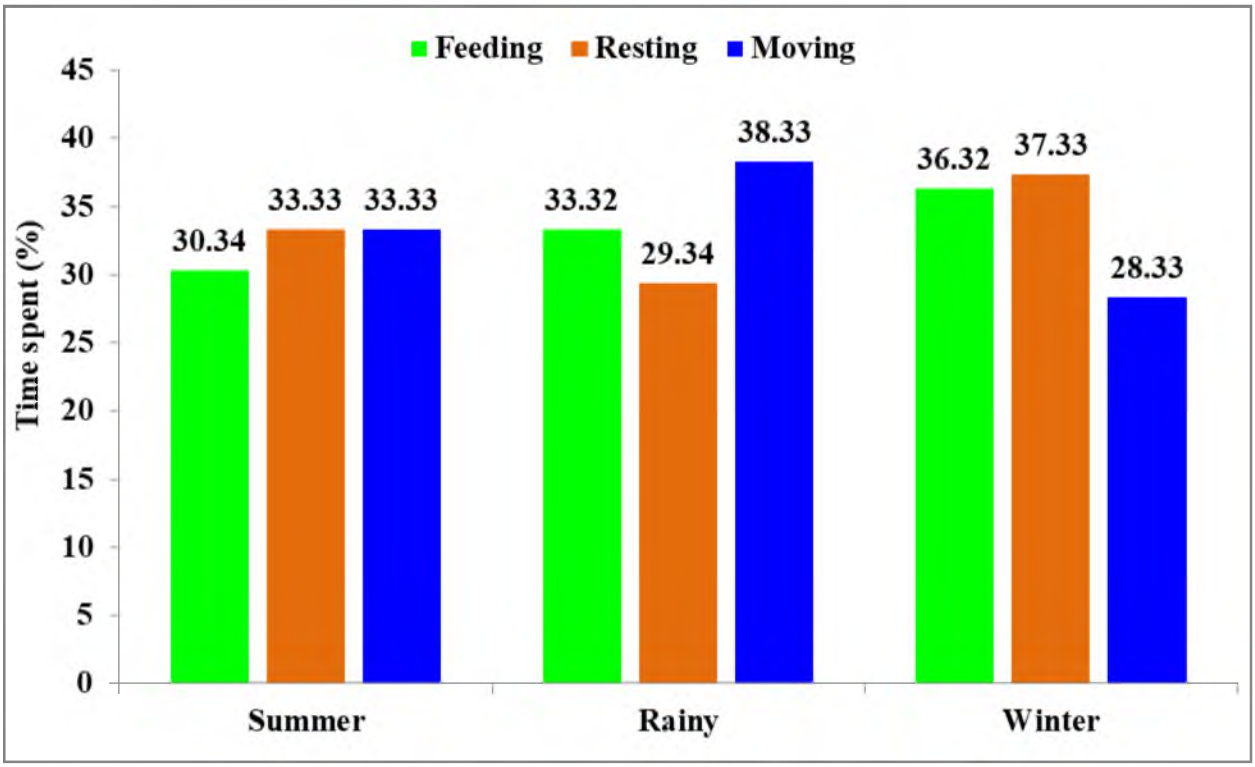


Fig. 4.49. Seasonal variation of activities of Asiatic Jackal.

Seasonality of behavioural activities

Feeding

There was significant differences in feeding time across the seasons ($F_{(2,15)}$=8.796, P=0.003, P<.05) (Fig. 4.50) (Appendix-XIII).

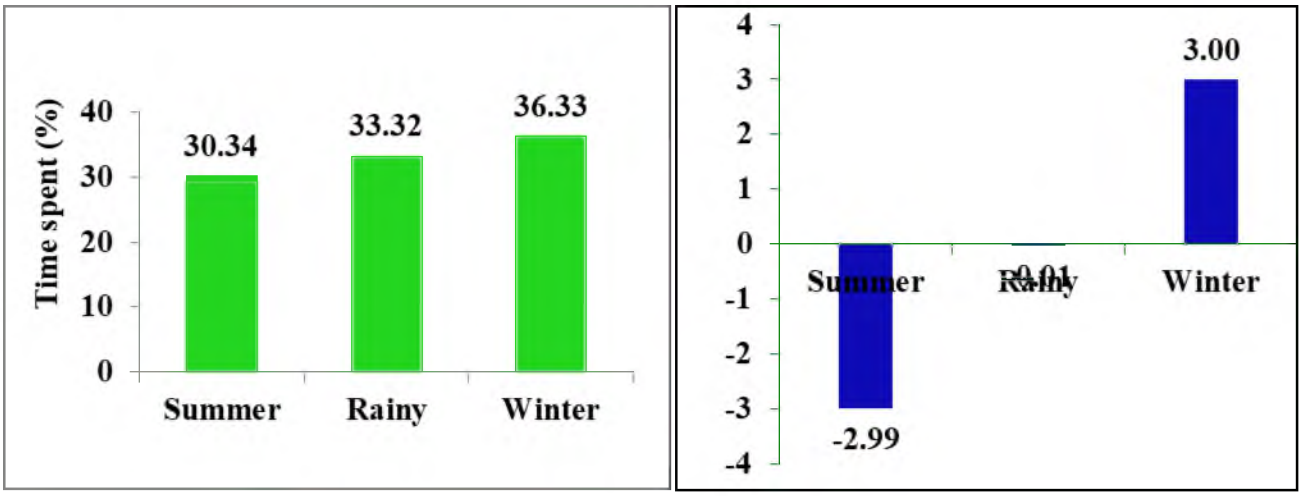


Fig.4.50. Seasonal variation of feeding of Asiatic Jackal.

Resting

The time spent of resting was significantly varied across the seasons ($F_{(2,15)}$=41.897, P=0.000, P<.05). The Asiatic Jackal spent more time in resting during winterseason and less time during rainy season (Fig. 4.51).

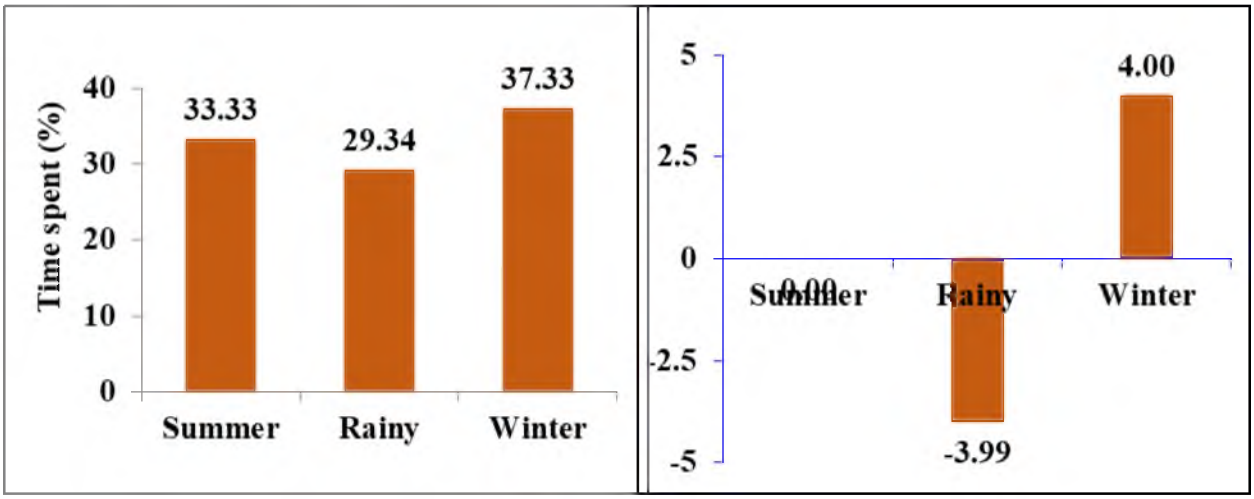


Fig. 4.51. Seasonal variation in resting activity of Asiatic Jackal.

Moving

There was significant difference in time spent of moving among the seasons ($F_{(2,15)}$=12.609, P=0.001, P<.05).

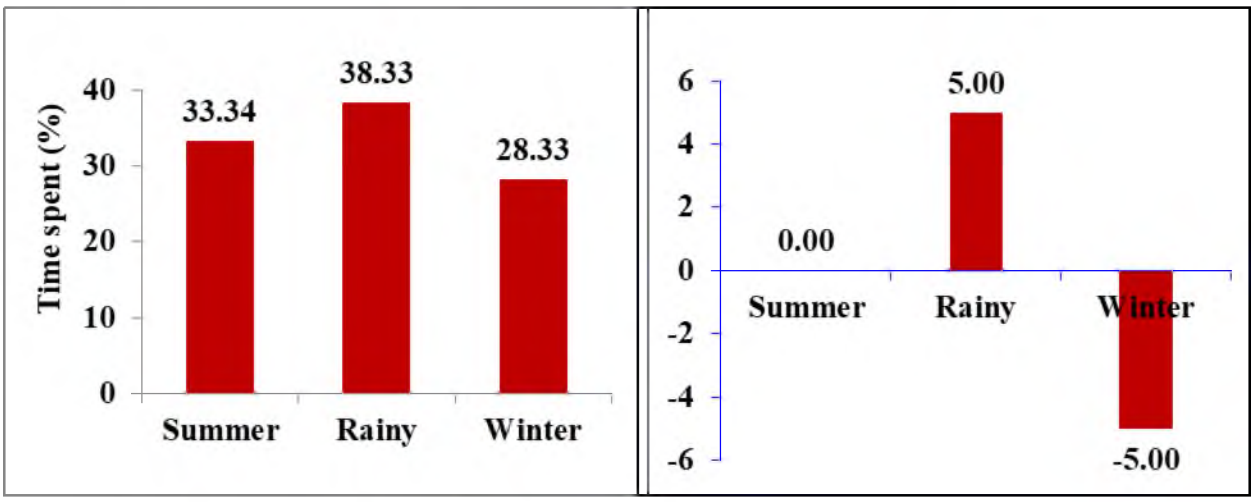


Fig. 4.52. Seasonal variation in moving activity of Asiatic Jackal.

Chapter 5

DISCUSSION

This study was carried out to know the patterns of behaviour (feeding, resting, moving and grooming) of Western Hoolock Gibbon (*Hoolock hoolock*), Asiatic Black Bear (*Ursus thibetanus*) and Asiatic Jackal (*Canis aureus*) in captive condition and to understand their behavioural biology related with captive surroundings. This study revealed that, different behaviours of captive animal vary diurnally, monthly and seasonally in relation to the varying degree of temperature. Impacts of the presence of visitors on the behaviour and age class differences in consuming of food, passing inactive time, moving and showing social activities like grooming were observed throughout the observation. Here is to interpret the result of my observation on the activity pattern of Gibbon, Bear and Jackal in Bangladesh National Zoo. What factors influence the feeding, resting, moving and grooming behaviour in the enclosure and to what extent the behaviours change across the different time blocks, months and seasons are to be discussed in this chapter. I analyzed the significant differences in diurnal and seasonal feeding, resting, moving and grooming beahviour of Western Hoolock Gibbon (*Hoolock hoolock*), Asiatic Black Bear (*Ursus thibetanus*) and Asiatic Jackal (*Canis aureus*) in captivity. I compared the autogrooming and allogrooming of Gibbon to assess the significant variance. The relationship between major activities were shown and I compared the observed data with the existing literature of on this species (Feeroz and Islam 1992, Chivers 197, Islam and Choudhury 2018, Zarzo-Arias et al.2018).

5.1. Western Hoolock Gibbon

5.1.1. Diurnal variation of behavioural activities of Hoolock Gibbon

Showing daily and seasonal variation in behavioral patterns is a common phenomenon for many species (Brager 1993), that helps them to maintain a balance in expending energy (Boness 1984). Activity patterns change is proportionate to this balance changes resulting a complex concession between requirements related to feeding, resting, reproduction (Nielsen 1983). The proportion of time an animal spent in different major activities that are important for its survival has defined as activity budget (Dunbar 1976). In a day Gibbons utilized the highest amount of time in resting followed by moving, feeding, playing, grooming.

Feeding

Allocation of time in different activities performed by the animal depends on widely daylight hours, temperature, limited space and available resources (Stanford 1991). Gibbons spent the highest time in feeding (51.88%) in the morning than the other part of the day which is close to the statement of Feeroz and Islam (1992) that feeding activity of Gibbons was high during the first half of the day. Probably due to remain starve whole life they showed more cravings for food during this time block of a day. Being a frugivorous diet of Gibbons encompasses with 50% to 75% of fruit followed by leaves (29%), flowers (7%), and insects (1%) (Chivers 197, Islam and Feeroz 1992). The sub adult female Gibbon spent the highest time for feeding (57.96%) in the morning. The reason could be predicted that animals were probably hungrier after passing overnight without food. Hoolock Gibbon spent less time for feeding in captivity and this findings showed dissimilarities with another study conducted previously on this species in the wild by the Islam and Choudhury (2018) and they stated that Gibbons invest 33.6% time in feeding of their active time in Assam, India. Thus, under captive conditions, feeding and foraging generally account for a lesser proportion of primates' daily activity than in the wild, as foraging is usually the major determinant of patterns of primate activity (Carlstead 1996) in the wild. The probable reason behind this may be the spatial and seasonal distribution of foods in an irregular manner in the wild (Oates 1987) and the travels of an individual from one resource block to another each take a certain amount of time. In contrast the captive condition did not allow spatial distribution of food which would lead to natural foraging patterns, thus, captivite Hoolock Gibbons needed not to worry about the foraging of food and other aspects related to more prolonged food consumption patterns like inter-species struggle, predation, or climatic conditions (Schwitzer and Kaumanns 2003) .

Resting

Resting was marked as inactive behaviour and the studied Gibbons were tended to be active in the morning and inactive in the afternoon. In captive animals, feeding time decreases and resting time increases (Melfi and Marples 2000, Veasey et al. 1996). The highest resting time (72.89%) was recorded in the afternoon and the lowest in the morning (7.83%). As captive Gibbons spent more time in moving, howling and hanging in the morning. Besides, most studies show that the presence of the visitors in zoos has a adverse impression on animal behaviour, such as increasing inactive behaviour and reducing social interactions (Chamove 1988) .The more time animals spend

in one behavioural state will decrease the amount of time devoted to other behaviours that may nonetheless be crucial to their survival. The sub adult Gibbon spent less time in resting than the adult. Abrams (2019) predicted that with the age, the female became thinner and started to lose strength in their legs and increased the resting time. The adult spent the highest amount of time in resting (80.46%) during afternoon but the sub adult showed more time spent in resting than that the adult did at noon (29.96%). Wild Gibbons invest less time in resting while their captive counterpart spent more time for this activity (Islam and Choudhury 2018). Usually, animals living in the wild spend less time in resting as the utilization of food items and the movements from one resource point to another each take a certain amount of time (Altmann 1979).The factors that influence the resting time in the wild are climate, availability of food source and dietary considerations (Korstjens et al. 2010). On the other hand, the captive Gibbon had lot of time for resting other than foraging as they were provided with enriched and processed provisioned food. The resting time was influenced by the temperature variation, as the highest resting was observed when the temperature was at its highest peak. This statement is close to the findings of Stelzner1988 stated that animals tend to rest more when temperatures are high.

Moving

The moving was the highest (67.96%) for captive Gibbon in the morning than other part of the day. They moved around the enclosures and kept howling to let the other caged Gibbons know about the territory or fortify family bond as mentioned by Ham et al. (2017). Besides the Zoo visitor group size affects the locomotion behaviour of captive gibbons (Hosey and Druck 1987; Orgeldinger 1997). The aged female Gibbons showed less time spent moving in noon than the sub adult in the morning and afternoon. Perhaps, to avoid the interaction with the dominant individual the sub adult moved more during this time period. Whereas the sub adult moved less than the adult female Gibbon in the noon period. May be the moving activity of higher ranking member of a group suppressed the moving of lower ranked individual.

Grooming

Grooming is one of the important characteristics in case of social animal. To establish social networks and relationships, is considered as one of the crucial purposes of social grooming. In the formation and maintenance of social bonding primates use grooming as the major social significant tool (Schino 2001). Tiddi et al. (2012) predicted that lower ranking individual grooms a higher ranking individual in the primate group. The result of this study does not support this prediction as the adult female showed more grooming behaviour throughout the day than the sub adult female Gibbon. This may be explained as stereotypic behaviour of aged Gibbon evolved due to captivity (Cheyne 2006). However, the females Barbary Macaques choose their grooming mates based on whom they know better rather than on social rank (Roubova et al. 2015). The wild Savannah Baboons use social affiliations to enhance fitness by increasing tolerance from more dominant group members (Henazi and Barrett 1999). But unfortunately, in Bangladesh National Zoo due to lack of proper social group the existing captive species were depriving from tremendous advantages of grooming. The highest (40.38%) grooming (autogrooming and allogrooming) was recorded by the captive Gibbons in the afternoon and the lowest in the morning (33.36%), as a result the moving time spent was decreased in the afternoon.

5.1.2. Monthly variation in behavioural activities of Hoolock Gibbon

The captive Gibbons showed the highest feeding activity in the month of May while they ate comparatively less amount of food in January. May was the hottest month during the conservation period and they were provided more food during this time because of the long day period. In contrast they showed less interest in feeding during the coldest months. It was recorded that Gibbons increased resting time in the month of August and it was the lowest in May. The probable reason could be that there was a decreasing number of visitors in the August month due to high rainfall and the presence of visitors was in the month the resting activity decreased. As a consequence, the time spent moving was the lowest in August (21.2%) while the highest was in April (29.5%). By contrast, the lowest grooming was observed in April but the highest was in the month of December.

5.1.3. Seasonal variation in behaviour of Hoolock Gibbon

Seasonal availability of foods is related to the feeding and resting behavior in primates (Masi et al.2015). Seasonality of activity budgets shows that Gibbon spent the highest time in feeding (38.32%) in summer and the lowest (27.45%) in winter. Because due to long day length in summer and for providing the extra provisioned food (400-500 g more food than other seasons) the Gibbon got the opportunity to intake more food. Whereas the wild counterparts spent the more time in foraging and feeding during winter in Bangladesh stated by Feeroz and Islam (1992). The highest resting time (38.03%) was recorded in rainy season and the lowest in summer. As stated, before during the rainy season the Zoo remained crowd free than the other seasons, probably due to this change there was changing pattern in resting behaviour. On the other hand, in the summer season the crowd made the caged animals show less resting behaviour. But from the findings of Mandl et al. (2018) primate individuals spent significantly less time resting in the late wet season than during any other period. The moving was the highest (37.66%) during summer and the lowest in rainy season. But the study carried out by Fan et al. (2013) in National Park, Indonesia stated that specially during winter season, Gibbon spent longer time in moving while searching food like fruits, leaves or insect because of food's unavailability. In a study by Meyers and Wright (1993), primates decreased their daily path lengths during the dry season. Besides Mandl et al. (2018) suggested that the locomotion of primate was highest in the late wet season compared to the rest of the year. Seasonally the highest (43.13%) grooming was recorded during winter and the minimum was during summer (22.22%). Probably to improve thermal competence they groomed more during winter as McFarland et al. (2015) projected that animals with more social relationship stay warmer in winter than the animals with fewer social relationships.

5.1.4. Temperature affects the behaviour of Hoolock Gibbon

When the average temperature was 29^0C the highest feeding occurred and it was the lowest when mean temperature went down to 19.5^0C. When temperature increased the studied Gibbons got more opportunity to eat the provisioned food for longer period of time and in contrast when temperature fell specially in the winter seasons the animals had shorter day to finish the given food. During the observation period it was noticed during excessive high temperature (average 29.5^0C) the maximum resting and the minimum moving occurred. Feeding activities was negatively correlated with the presence of visitors. For instance, when number of visitors was less than 10 it was found that Gibbon spent the highest time in feeding. In contrast, the feeding time

was dramatically decreased when the number of visitors increased more than 20. Because the captive Gibbons got influenced to show playful behaviour when crowd increased. As a result, they reduced feeding and resting time at that period. When the number of visitors < 20 persons, the moving time was decreased with the decreasing number (below 20) of crowds, the Gibbon started to spend less time in moving.

5.2. Asiatic Black Bear (*Ursus thibetanus*)

5.2.1 Diurnal variation of behavioural activities of Asiatic Black Bear

Feeding

The highest feeding (86.91%) was recorded in the noon. No feeding of Asiatic Bear was recorded in the morning, as foods were provided between 11.30am and 12.30pm to them in the Bangladesh National Zoo. Because of remaining very hungry since morning, the highest intake of food was observed at noon. Rest of the foods were finished in the afternoon, when the time spent in feeding was 12.88%. Wild bears spent more time on foraging and feeding (54%) (Zarzo-Arias et al. 2018) than their captive counterpart. Wild bears paid almost 80% time of their active time in foraging or feeding (Lorenzo 2009). This statement is close to the predictions of Morimura and Ueno 1999 that feeding ecologies of caged animal differed a great deal from those in the wild. Actually, there was no insecurity about the searching of food in captivity, as a result caged individual spent comparatively less time in feeding.

Resting

The housed Black Bear showed the highest resting (62.74%) activity in the afternoon. They took rest less in the morning. Probably because of not having food they decreased the resting behaviour as they became restless in the morning. On the other hand as they remained full content, after finishing the remaining food in the afternoon they spent their most of the time in resting in the afternoon. In contrast, the wild bear invests only 9.67% of time in resting (Zarzo-Arias et al.2018). As feeding and locomotion consume most of their time in forest habitat, the time remains for resting and social activities is less in the forest group.

Moving

The time spent moving (49.08%) was the highest in the morning and the lowest in the afternoon. As mentioned earlier about their restless behaviour in the morning they moved here and there in the enclosure in searching of food perhaps because of that the moving time spent increased. Although such type of frequent pacing is considered as stereotype behaviour (Mason and Latham 2004)The moving time decreased in the afternoon because of the occurrence of the highest resting activity. The wild bear spent less time in moving (without foraging) than the housed bear (Zarzo-Arias et al.2018). Because, most of the time of wild group are occupied in feeding and foraging behaviour.

5.2.2. Monthly variation of behavioural activities (Asiatic Black Bear)

The Asiatic Black Bear spent the highest time in feeding during December (31.00%). December was the coldest month and the Bears consumed more food during this period, they finished their food in the months of cold more faster than the other months. In contrast, being one of the hot months the lowest amount of feeding occurred in the month of May (17.30%). The resting behaviour was also recorded maximum in the month of December and the lowest in May. As May was the warmest month, the highest moving occurred and in the month of January the lowest moving was recorded (moving and resting behaviour negatively correlated).

5.2.3. Seasonal variation of behavioural activities (Asiatic Black Bear)

A variety of strategies are followed by the living things to adjust to the seasonal environmental (temperature, light conditions and nutrient or water availability) factors like reproduction happens when the period is in favor (Eccard and Herde 2013). The captive bears spent more time in feeding during winter (18.97%) than the other season. During summer season, the feeding activity had been identified as second major activity. It was noticed that the Asiatic Bear finished the given provision food at once during winter while in the other part of the year some of the foods remained left to be finished in the afternoon. That's why they were provided extra seasonal food and honey to maintain the body temperature during winter part. May be during this time their body temperature remained under control that's why they felt relaxed to have more food. In contrast they spent less time in feeding in the summer. The possible reason could be because of their increasing body temperature, they showed less interest in intaking of food. In fact, in Bangladesh National Zoo, the captive Asiatic Black Bears were provided lemons to minimize

the body temperature. The captive Black Bears were more active in summer than the winter season as the resting time spent was the highest in the winter than the summer season as previously reported in Taiwan, (Hwang and Garshelis 2007). During winter season because of increasing body temperature, they became restless resulting increasing moving record than the other season. While in the summer they moved less. These results support the findings by Lan et al. 2011 who respectively found that in captive condition during summer season the lowest and during winter the highest moving of bear occurred.

5.2.4. Temperature affects the behaviour of Asiatic Black Bear

The time spent in different behaviour was also varied with temperature and the number visitor in the zoo. When the temperature was 20.5^0C, the Asiatic Black Bears were less active as during this climatic condition the highest feeding and resting was observed. The Grizzly bears (*Ursus arctos*) become less active and more nocturnal when ambient temperature exceeds 20°C (McLellan and McLellan 2015). In contrast, the highest time spent moving and grooming was recorded when the average temperature was 29^oC.

5.3. Asiatic Jackal (*Canis aureus*)

5.3.1 Diurnal Variation of behavioural activities of Asiatic Jackal

The Asiatic Jackal spent the maximum time in moving 29.29%, 15.43% in resting, 12.52% in feeding and 42.76% time in other activities. Although Asiatic Jackal is a nocturnal animal but they showed diurnality (Gupta et al. 2016). To understand the behavioural ecology, one of the important ways is to know the proportion of time spent by the animal in various activities throughout the day (Clutton–Brock 1974). In the wild the great majority of the animals were diurnal but to optimize themselves in the competitive field like gaining of resources easily and to escape from predators many animals specially mammals were forced to nocturnality (Joffe et al. 2014). Being a nocturnal animal in captivity during day hour the Jackals spent less time in feeding than the other behaviour, whenever they saw anyone coming towards the cage they went back inside the cage. Thus, the moving time was longer.

5.3.2. Monthly variation in behavioural activities of Asiatic Jackal

The Jackal amplified the feeding behaviour in the cold months, by contrast, during excessive hot weather they decreased the intake of food. As a result, the highest feeding occurred in the month of January while the lowest in May. The time spent resting was the highest in December while the lowest was observed in the month of September. Captive Asiatic Jackal invested the maximum time in moving in the month of August and the minimum in December.

5.3.3. Seasonal variation in behavioural activities of Asiatic Jackal

During summer Asiatic Jackal spent less time (30.34%) in feeding may be because of hot weather because during winter season they quickly finished the food while in the summer season they were observed to eat the food even in the night by the zoo staff. They moved more during rainy season (38.33%) than the other season. But according to the study in Pakistan carried out by Mahmood (2013) Jackal eat more during summer season because of availability of diverse food source. Jackals utilized the highest amount of time spent in resting during winter season. Whereas the minimum time spent was recorded during rainy season.

Chapter 6

SUMMARY

6.1. Western Hoolock Gibbon

6.1.1. Diurnal activities

Most of the feeding of captive Gibbon was observed in the morning. While adult both the adult and subadult Gibbon spent less time in the afternoon. They preferred to invest most of their time in resting in the afternoon while the lowest resting time spent was recorded in the morning. The sub adult utilized more time in resting in the noon than the adult Gibbon. The highest amount of time was spent in moving in the morning. In the morning the time investment was in autogrooming was more than the allogrooming while in the afternoon the later one was the highest. The sub adult showed more time expenditure in grooming both in the morning and noon period than the adult. Wild Gibbon spent the higest time in feeding, grooming and moving than the captive counterpart (Islam and Choudhury 2018).

6.1.2. Monthly variation

Caged Gibbons spent the highest amount of time in feeding in the month of May, whereas they were recorded to invest the lowest amount of time in January. The highest resting and the lowest moving were observed in the month of August. While the lowest spent time on resting and the highest on moving was reported in the month of May and April respectively. Grooming was mostly occurred in the month of December, and the lowest time spent was in April (20.2%). With the increasing number of visitors resting time spent gradually decreased and the movoing gradully speeded up.

6.1.3. Seasonal variation

Gibbons were found to spend highest amount of time in resting during rainy season than other parts of the year, and the lowest percentage was recorded during summer. In contrast feeding and moving behaviour were the highest during summer season. Majority of the grooming occurred during winter season while the lowest was in the summer.

6.2. Asiatic Black Bear

6.2.1. Diurnal variation

The studied bear spent the highest amount of time in resting followed by feeding ,moving and grooming. They were noted to spend the highest amount of time in feeding in noon. In the morning the moving value was the highest than other parts of the day. The highest resting time spent was observed in the afternoon.

6.2.2. Monthly variation

In the month of December, the highest feeding and resting occurred, while the lowest was in May. The bear showed the highest moving in May. While during the month of April the highest grooming time spent was recorded.

6.2.3. Seasonal variation

Bears utilized the highest amount of time in resting and feeding during winter season than other parts of the year. They showed the lowest food intake in summer season. By contrast in the summer season, time spent on the moving and grooming was the highest and during rainy season the lowest time spent was recorded.

6.3. Asiatic Jackal

6.3.1. Diurnal variation

During the observation time the Asiatic Jackal spent the highest time in moving followed by resting and feeding.

6.3.2. Monthly variation

Asiatic Jackal spent the maximum time in feeding and resting in the month of January and December respectively. The lowest time spent was observed in May and September. The moving time spent was the highest in August while the minimum was in the December.

6.3.3. Seasonal variation

In all the three seasons the time spent on moving was at the highest peak. The highest time spent in moving was observed in rainy season while the lowest was in the winter season. In contrast the highest amount of time spent for resting occurred in winter season and the lowest was during rainy season. Like the resting the peak feeding value was noted down during winter season while the lowest was in the summer.

Chapter 7

CONCLUSION AND RECOMMENDATION

CONCLUSION

Internal and external mechanisms shape the behaviors of an animal, which help the animal acclimate to a specific environment. Encouraging natural behaviours that animals feel motivated to express is extremely important for good animal welfare. An animal will flourish in captivity if the captive atmosphere offers environmental selections that permit the animal to express normal behaviours that the animal feels motivated to commence. It is worth mentioning here, the present study of the captive animals revealed that environment was one of the major factors responsible for the variation in behavioural activities. The behavioural observation of Western Hoolock Gibbon, Asiatic Black Bear and Asiatic Jackal of Bangladesh National Zoo during different time period of a day, months and seasons of the present study give a glimpse about how animals interact with, respond to, and adapt their captive environment. The outcomes of the study may aid in enhancing behavioural diversity that leads to a superior level of welfare, by introducing natural supplements and utilizing the full use of enclosure make them feel it like their wild habitat. This study also provides new insight into species biology and by the comparison the captive species with the wild species, their diversion from natural behaviour can be known and what pragmatic steps should be followed to minimize the deviation as soon as possible that will be fruitful for their reproductive and genetic biology and ultimately the conservation, management and reintroduction program will be successful. However, further studies are necessary to explore the potential differences in behaviour at night between the wild-caught and the captive-born animals, and to explore appropriate management practices for captive populations.

Recommendation

The goal of the study was to collect behavioural data on diurnal, seasonal and monthly basis of Western Hoolock Gibbon, Asiatic Black Bear and Asiatic Jackal was nearly achieved. But yet, there were some limitation that came across into the completion of this research work. For instance,

- The lack of sex ratio was an area of major concern. In captivity, the breeding data, that has been collected from proper sex ratio, are very crucial to rise the population to a satisfactory size, to avoid extinction also for the reintroduction of the threatened or critically endangered

animal in the wild (Lambertucci et al. 2013). So, population with sex structure that encourages consistent reproduction should be maintained.

- The next hindrance was absence of proper age group in case of social animal, to have a proper age class composition or social group is very important that influences the social animal to show different types of social behaviour like aggregations, cooperation in sexual or parental behaviour, fighting, sharing of food, grooming, dispute over territory or mating pair and simple communication like the wild animals do (Williams et al. 2019).
- The size and infra-structure of the cage should be like their natural habitat rather than artificial.
- From the observed data it was analyzed that the captive Gibbon spent less time in feeding because the food was given them in a fixed place and in the same manner, that did not require to spend time in searching food. So, the provision food should be supplied them in different unknown points or pockets in scattered manner instead of giving in a fixed place, that will force them to search food as a result the foraging and feeding time will be increased which would have a positive impact on the time spent on other behaviour. The feeding schedule should be unpredictable to lengthen feeding and foraging.
- Although the selected captive animals were provided food rich with nutritional value, but the food should reflect their natural wild diet because such practice influences species specific natural manner of feeding (Cocks 2000).
- As we know that Gibbons and bear are good climber, so, climbing materials will aid in swinging and climbing behaviour. Large tree with branches should be installed in the cage for swinging and climbing and the material should be like that will be helpful for their muscle development. In order to exhibit specie specified activities like in Gibbon the brachiation ad swinging Branches play an important role (Reinhardt & Smith, 1988).
- Natural supplements should be used on rotation basis so that the caged animal use more time in finding the enrichment tools.
- The distance of the cage should be out of the reach of the visitors as sometimes the caged animal become irritated with the behaviour and the presence of visitors.

- There should be burrowing opportunities in the cage specially in the cage of Jackal. As we know Jackals have the tendency to store the extra food by burying (Kingdom 1977).
- Being a nocturnal animal, the Jackals remained either sleeping or hiding during daytime. so, more studies should be carried out in future on the nocturnal behavioural patterns of Jackal in captivity at night, interaction of captive species with the visitors, behavioural response of captive animal with zero audience by installing video cameras in the cage, impacts of natural enrichment in developing the behaviour of captive species and cause of stereotype behaviour of Asiatic Black Bear in captivity.

Chapter 8

REFERENCES

Abram, S. 2019. Western hoolock gibbon *Hoolock hoolock*. New England Primate Conservancy. https://www.neprimateconservancy.org/western-hoolock-gibbon.html. Downloaded on 5-09-2020.

Ahmadzadeh, F., Liaghati, H., Kiabi, B.H., Mehrabian, A.R., Abdoli, A. and Mostafavi, H. 2008. The status and conservation of the Asiatic black bear in Nikshahr County, Baluchistan District of Iran. *Journal of Natural History*. 42(35-36): 2379-2387.

Ahsan, M.F. 1994. *Behavioral ecology of the hoolock gibbon in Bangladesh*. PhD Dissertation. University of Cambridge, Cambridge, UK.

Akers, A.A., Islam, M.A. and Nijman, N. 2013. Habitat characterization of western hoolock gibbons Hoolock hoolock by examining home range microhabitat use. *Primates*. 54: 341–348.

Ali, A., Zhou, Z., Waseem, M., Khan, M.F., Ali, I., Asad, M. and Qashqaei, A.T. 2017. An assessment of food habits and altitudinal distribution of the Asiatic black bear (*Ursus thibetanus*) in the Western Himalayas Pakistan. *Journal of Natural History*. 51: 689-701.

Altmann, J. 1980. *Baboon Mothers and Infants*. Cambridge, Harvard University Press. Xiv, pp 242

Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour*. 49: 227-267.

Bangladesh Water Development Board. 2019. SUMMARY OF RAINFALL IN BANGLADESH FOR THE YEAR 2017 & 2018. Surface Water Processing Branch BWDB, 72 Green Road, Dhaka.

Bear Specialist Group 1996. *Melursus ursinus*. *In*: IUCN 2007. IUCN Red List of Threatened Species. Version 2007. <www.iucnredlist.org> Downloaded on 21 January 2008.

Bernstein, I.S. 1980. Activity patterns in a Stumptail Macaque Group (*Macaca arctoides). Folia Primatologica*. 33: 20-45.

Bishop, J., Hosey, G. and Plowman, A. 2013. *Handbook of zoo research, guidelines for conducting research in zoos*. London. *BIAZA*. Pp. 134-153.

Bob Humphreys. 2018. Field judging Black Bear. Mossy Oak.

Boness, D. J. 1984. Activity budget of male grey seals, *Halichoerus grypus*. Journal of Mammalogy, 65, 291-297. http://dx.doi.org/10.2307/1381168

Boskovic, I., Ozimec, S., Speranda, M., Sprem, N., Degmecic, D., Curovic, M., Spalevic, V. and Florijancic, T. 2015. Morphometric characteristics of the golden jackal populations in Eastern Croatia and Eastern Serbia. *Agriculture & Forestry*. 61(3). pp. 61-68.

Bowkett, A.E. 2009. Recent captive-breeding proposals and the return of the ark concept to global species conservation. *Conservation Biology*. 23(3). 773-776.

Brager, S. 1993. Diurnal and seasonal behaviour patterns of bottlenose dolphins (*Tursiops truncatus*). Marine Mammal Science, 9, 434-438. http://dx.doi.org/10.1111/ j.1748-7692.1993.tb00477.x

Bridges, A.S., Vaughan, M.R. and Klenzendorf, S. 2004. Seasonal variation in American black bear *Ursus americanus* activity patterns: quantification via remote photography. *Wildlife Biology*. 10: 277–284.

Brockelman, W.Y., Reichard, U., Treesucon, U. and Raemaekers, J.J. 1998. Dispersal, pair-formation and social structure in gibbons (*H. lar*). *Behavioral Ecology Sociobiology*. 42: 329–339.

Brown, G. 1993. The Great Bear Almanac. Lyons & Burford. ISBN 978-1-55821-210-7.

Carlstead, K. 1996. Effects of captivity on the behavior of wild mammals. In: Wild Mammals in Captivity – Principles and Techniques (D. G. Kleiman, M. E. Allen, K. V. Thompson, S. Lumpkin, eds.). *Chicago and London: The University of Chicago Press*, pp. 317–333.

Chamove, A.S., Hosey, G.R. and Schaetzel, P., 1988. Visitors excite primates in zoos. Zoo biology, 7(4), pp.359-369.Cheyne, S.M. 2006. Unusual behaviour of captive-raised gibbons: implications for welfare. *Primates*. 47(4). pp. 322-326.

Chivers, D.J. 2005. Gibbons: the small apes. *World atlas of great apes and their conservation*. Berkeley: University of California Press. pp. 205-214.

Choudhury, A. 1990. Population dynamics of Hoolock Gibbons (Hylobates hoolock) in Assam, India. *American Journal of Primatology*. 20(1): 37-41.

Choudhury, A. 1991. Ecology of the Hoolock Gibbon (Hylobates hoolock), a lesser ape in the tropical forests of north-eastern India. *Journal of Tropical Ecology*. 7(1): 147-153.

Choudhury, A. 1996. A survey of Hoolock Gibbon (*Hylobates hoolock*) in southern Assam, India. *Primate report*. 44: 77-85.

Choudhury, A. 2001. Primates in northeast India: An overview of their distribution and conservation status . ENVIS Bulletin: *Wildlife and Protected Areas*. 1(1): 92-101.

Choudhury, A. 2004. Vanishing habitat threatens Phayre"s leaf monkey. *The Rhino Foundation. NE India Newsletter*. 6: 32-33

Choudhury, A. 2006. The distribution and status of Hoolock Gibbon (*Hoolock hoolock*) in Manipur, Meghalaya, Mizoram, and Nagaland in Northeast India. *Primate Conservation*. 20: 79 87.

Choudhury, A. 2009a. The distribution, status and conservation of Hoolock Gibbon *Hoolock hoolock* in Karbi Anglong District, Assam, Northeast India, *Primate Conservation*. 24: 117-126.

Choudhury, A. 2009b. The Hoolock Gibbon (*Hoolock hoolock*) in Tinsukia and Dibrugarh Districts of Assam, India. *Asian Primates Journal*. 1(2): 24-30.

Choudhury, A.U. 2013. Records of Asiatic black bear in North East India. Final report to International Association for Bear Research Management (IBA). *The Rhino Foundation for nature in NE India, Guwahati, Assam, India*. pp. 96.

Clutton-Brock, J., Corbet, G.B. and Hills, M. 1976. A review of the family Canidae, with a classification by numerical methods. *Bulletin of the British Museum (Natural History) Zoology*. 29: 1–199.

Clutton-Brock, T.H. 1974. Activity pattern of Red Colobus (*Colobus badius tephroscele*). *Folia Primatologica*. 21: 161-187.

Cocks, L. 2000. Husbandry Manual for the Javan Gibbon (*Hylobates moloch*). *Perth Zoo*. 24 pages.

Cowlishaw, G. 1992. Song function in gibbons. *Behaviour*. 121: 131–153.

Crompton, R.H., Vereecke, E.E. and Thorpe, S.K.S. 2008. Locomotion and posture from the common hominoid ancestor to fully modern hominins, with special reference to the last common panin/hominin ancestor. *Journal of Anatomy*. 212: 501- 543.

Das, J., Bhattacharjee, P.C., Biswas, J. and Chetry, D. 2004. Western Hoolock Gibbon: Socioecology, Threats and Conservation Action Plan. *A report of Primate Research Center, Gauhati University, Assam. India.* 70 p.

Dawkins, M.S. 1998. Evolution and animal welfare. *The Quarterly Review of Biology*. *73*(3): 305-328.

Defler, T.R. 1995. The time budget of a group of wild woolly monkeys (*Lagothrix lagothricha). International Journal of Primatology*. 16: 107–120.

Dhaka maps 2016. dhaka map by road-map of dhaka city-dhaka city map. https://images.app.goo.gl/WBy8RRCHHzLQ6Bhw9.

Dhaka Zoo. 2020. http://www.dhaka.gov.bd/site/tourist_spot/d949c95f-2014-11e7-8f57-286ed488c766/%E0%A6%A2%E0%A6%BE%E0%A6%95%E0%A6%BE%20%E0%A6%9A%E0%A6%BF%E0%A6%A1%E0%A6%BC%E0%A6%BF%E0%A6%AF%E0%A6%BC%E0%A6%BE%E0%A6%96%E0%A6%BE%E0%A6%A8%E0%A6%BE. Downloaded. 4-12-2020.

Dunbar, R.I.M. 1976. Some aspects of research design and their implication in the observation study of behavior. *Behaviour*. 58(1-2): 78-98.

Eberhart, G.M. 2002. *Mysterious Creatures: A Guide to Cryptozoology*. ABC-CLIO.

Eccard, J.A. and Herde, A. 2013. Seasonal variation in the behaviour of a short-lived rodent. *BMC Ecol*. 13(1): 43. doi./10.1186/1472-6785-13-43

Estrada, A., Garber, P.A., Mittermeier, R.A., Wich, S., Gouveia, S., Dobrovolski, R., Nekaris, K.A.I., Nijman, V., Rylands, A.B., Maisels, F. and Williamson, E.A. 2018. Primates in peril: the significance of Brazil, Madagascar, Indonesia and the Democratic Republic of the Congo for global primate conservation. *Peer-reviewed journal*. 6, p.e4869.

Fan, P.F., Ai, H.S., Fei, H.L., Zhang, D. and Yuan, S.D. 2013. Seasonal variation of diet and time budget of Eastern hoolock gibbons (*Hoolock leuconedys*) living in a northern montane forest. *Primates*. Apr 1. 54(2): 137-46.

Feeroz, M.M. 2001. Species diversity and population density of non-human primates in northeast and south-east of Bangladesh. *Ecoprint*. 8: 53–57.

Feeroz, M.M., Hasan, M.K. and Khan, M.M.H., 2011. Biodiversity of Protected Areas of Bangladesh, Vol. I, Rema-Kalenga Wildlife Sanctuary. *BioTrack, Arannayk Foundation*, Dhaka. Pp. 214

Feeroz, M.M., Soliven, K., Small, C.T., Engel, G.A., Pacheco, M.A., Yee, J.L., Wang, X., Hasan, M.K., Oh, G., Levine, K.L., Alam, S.M.R, Craig, K.L., Jackson, D.L., Lee, E.G, Barry, P.A., Lerche, N.W., Escalante, A.A., Matsen IV, F.A., Linial, M.L. and Jones-Engel, L. 2013. Population dynamics of rhesus macaques and associated foamy virus in Bangladesh. *Emerging Microbes and Infections*. 2(1) 1-14. doi:10.1038/emi.2013.23

Feeroz, M. M., and Islam, M. A. 1992. Ecology and behaviour of hoolock gibbons of Bangladesh, MARC (Multidisciplinary Action Research Centre), Dhaka, Bangladesh. Pp. 76

Feroz, S.I., Alam, M.R.B. and Sakib, A.N., 2020. Effects of Global Emission of Greenhouse Gases-CO2, N2O, and CH4 on Climate Change of Dhaka City.

Garshelis, D.L. and Steinmetz, R. 2008. *Ursus thibetanus*. *In*: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. accessed 3 March 2013.

Ginsberg, J.R. and Macdonald, D.W. 1990. *Foxes, wolves, jackals, and dogs: an action plan for the conservation of canids*. Iucn. pp. 12-13

Geissman, T. 1991. Reassessment of age of sexual maturity in gibbons (*Hylobates* spp.). *American Journal of Primatology*. 23: 11–22.

Genov, P. and Wassiley, S. 1989. Der schakal (*Canis aureus* L.) in Bulgarian. Ein beitrag zu seiner verbreitung und biologie. *Zeitschrift fur Jagdwissenschaft*. 35: 145–150.

Giannatos, G., Karypidou, A., Legakis, A. and Polymeni, R. 2010. Golden jackal (Canis aureus L.) diet in Southern Greece. *Mammalian Biology*. 75(3). pp.227-232.

Gittins, S. and Tilson, R. 1984. Notes on the ecology and behaviour of the Hoolock Gibbon. *In*: H. Preuschoft, H., Chivers, D.J., Brockelma, W.Y. and Creel, N. (eds.). The lesser apes. Evolutionary and behavioural biology. Edinburgh University Press, Edinburgh, UK. pp: 258-266.

Golley, F.B. 1966. *South Carolina Mammals*. The Charleston Museum, Charleston, SC.

Goodman, M. 1999. The natural history of the primates. *American Journal of Human Genetics*. 64: 31–39.

Goodness, T. 2004. *Ursus thibetanus*. *In*: Myers P, et al., editors. Animal diversity web. Available from: http://animaldiversity.org/accounts/Ursus_thibetanus/ [Accessed 9 Apr 2021]

Grand, T.I. 1972. A mechanical interpretation of terminal branch feeding. *Journal of Mammalogy*. 53: 189–201.

Groves, C.P. 1967. Geographic variation in the hoolock or white-browed gibbon (*Hylobates hoolock* Harlan 1834). *Folia Primatologica*. 7(3-4). pp. 276-283.

Groves, C.P. 1972 Systematics and phylogeny of gibbons. *In*: Rumbaugh, D.M. (ed.). Gibbon and Siamang. Karger, Basel. 1.1-89.

Gupta, A.K. and Sharma, N. 2005. Conservation status of Hoolock gibbon (*Bunopithecus hoolock*) in Meghalaya. *Conservation of Hoolock Gibbon in Northeast India. ENVIS Bulletin: Wildlife and Protected Areas*. 8. pp: 87-150.

Gupta, S., Sanyal, A., Saha, G.K. and Ghosh, A.K. 2016. Diurnal activity pattern of Golden Jackal (Canis aureus Linn.) in an urban landscape of Kolkata, India. In *Proceedings of the Zoological Society*.Vol. 69,. No. 1. pp. 75-80. Springer India.

Ham, S., Lappan, S., Hedwig, D. and Choe, J.C. 2017. Female Songs of the Nonduetting Javan Gibbons (*Hylobates moloch*) Function for Territorial Defense. *International Journal of Primatology*. 38: 533–552.

Harlan, R. and Burrough, M. 1834. Description of a species of orang, from the north-eastern province of British East India, lately the Kingdom of Assam. Transactions of the *American Philosophical Society*. 4. pp.52-59.

Harrington, F.H. and Mech, L.D. 1979. Wolf howling and its role in territory maintenance. *Behaviour*. 68(3-4): 207-249.

Hasan, M.K., Feeroz, M.M., Islam, M.A., Kabir, M.M., Begum, S., Aziz, M.A. and Sarker, G.C. 2005. Food and feeding behaviour of hoolock gibbon (*Bunopithecus hoolock hoolock*) in a semievergreen forest of Bangladesh. *Bangladesh Journal of Life Science*, *17*(1), pp.43-49.

Hasan, M.K., Feeroz, M.M., Islam, M.A., Kabir, M.M. and Begum, S. 2007. Substrate use by the western hoolock gibbon (*Hoolock hoolock*) in a semievergreen forest of Bangladesh. *Zoos' Print Journal*. 22(6). pp.2702-2705.

Hasan, M.K. and M.M. Feeroz. 2011. Space sharing by Hoolock Gibbons (Hoolock hoolock) in Lawachara National Park, Bangladesh. In: Proceedings of the International Conference on Biodiversity – Present State, Problems and Prospects of its Conservation, University of Chittagong, Chittagong, Bangladesh, 8–10 January, 2011, E. Røskaft and D. J. Chivers (eds.). pp.44–48. Norwegian University of Science and Technology (NTNU), Trondheim, Norway.

Hasan, M.K., Aziz, M.A., Alam, S.R., Kawamoto, Y., Jones-Engel, L., Kyes, R.C., Akhtar, S., Begum, S. and Feeroz, M.M. 2013. Distribution of Rhesus Macaques (*Macaca mulatta*) in Bangladesh: Inter-population Variation in Group Size and Composition. *Primate Conservation*. 26: 125–132.

Hashimoto, Y. and Anrui, T. 2013. Summer food habits of the Asiatic black bears in Moor of Oze Area Central Japan. *Mammal Study*. 38: 235– 241.

Henazi, S.P and Barrett, L. 1999. The value of grooming to female primates. *Primates; Journal of Primatology*. 40 (1): 47–59. doi:10.1007/BF02557701 PMID 23179531. S2CID 3410663

Heptner, V. G., Naumov, N. P. 1998. Mammals of the Soviet Union Vol. II Part 1a, Sirenia and Carnivora (Sea cows; Wolves and Bears). Science Publishers, Inc. USA. ISBN 978-1-886106-81-9.

Hosey, G.R. and Druck, P.L. 1987. The influence of zoo visitors on the behaviour of captive primates. *Applied Animal Behaviour Science*. 18(1), pp.19-29.

Huber, D. and Manen, F.T. 2019. Bear Morphology. *In*: Vonk J., Shackelford, T. (eds.). *Encyclopedia of Animal Cognition and Behavior*. Springer, Cham. doi.org/10.1007/978-3-319-47829-6_1711-1

Hwang, M.H. and Garshelis, D.L. 2007. Activity patterns of Asiatic Black Bears (*Ursus thibetanus*) in the Central Mountains of Taiwan. *Journal of Zoology*. *271*(2). pp. 203-209.

International union for the conservation of nature Bangladesh. 2000. Red Book of threatened mammals of Bangladesh. International Union for the Conserva-tion of Nature, Gland, Switzerland.

Islam, M. and Choudhury, P. 2018. Activity profile of a group of Hoolock gibbon (*Hoolock hoolock*) in a fragmented forest of patch of Rosekandy tea garden, Barak valley, Southern Assam, India. *International Journal of Zoology studies*. 3(2). 307-313.

Islam, M.A. and Feeroz, M.M. 1992. Ecology of Hoolock Gibbon of Bangladesh. *Primates*. 33: 451–464.

Islam, M.A., Uddin M., Aziz M.A., Muzaffar S.B. and Chakma, S. 2013. Status of bears in Bangladesh: going, going, gone?. *Ursus*. 24(1): 83-90.

IUCN Bangladesh. 2000. *Red Book of Threatened Mammals of Bangladesh*. IUCN-The World Conservation Union. pp. xii+71.

IUCN. 2000. *Red Book of Threatened Mammals of Bangladesh*. IUCN-The World Conservation Union, Bangladesh. p. 31.

IUCN Bangladesh. 2015. Red List of Bangladesh Volume 2: Mammals. IUCN- The International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, pp. xvi+232.

Jacobs, T. 2018. "Belief in 'Balance of Nature' Hard to Shake". *Pacific Standard*. Retrieved 2020-03-20.

Jaeger, M.M, Pandit, R.K. and Haque, E. 1996. Seasonal Differences in Territorial Behavior by Golden Jackals in Bangladesh: Howling versus Confrontation. *Journal of Mammalogy*. 77(3): 768. doi:10.2307/1382682. JSTOR 1382682

Jaeger, M.M., Haque, E., Sultana, P. and Bruggers, R.L. 2007. Daytime cover, diet and space-use of golden jackals (*Canis aureus)* in agro-ecosystems of Bangladesh. *USDA National Wildlife Research Center* - Staff Publications. 701. https://digitalcommons.unl.edu/icwdm_usdanwrc/701

Joffe, B., Peichl, L., Hendrickson, A., Leonhardt, H. and Solovei, I. 2014. "Diurnality and Nocturnality in Primates: An Analysis from the Rod Photoreceptor Nuclei Perspective". *Evolutionary Biology*. 41(1): 1–11.

Jones, K.E. and Safi, K. 2011. Ecology and evolution of mammalian biodiversity. *Philosophical Transaction of the Royal Society*. 366: 2451-2461.

Kakati, K. 2004. *Impact of forest fragmentation on the hoolock gibbon in Assam, India*. PhD thesis, University of Cambridge, Cambridge, UK.

Kakati, K. 2006. Fragment-living- a study of hoolock gibbons in Assam, India. *The Gibbon"s Voice*. 8(1): 1-4.

Kemmerer, L. ed. 2015. *Bear Necessities: Rescue, Rehabilitation, Sanctuary, and Advocacy. Brill.* pp.27.

Khan, M.A.R. 1982. *Wildlife of Bangladesh*: a checklist. University of Dhaka; Dhaka, Bangladesh.

Khan, M.A.R. 1985. *Mammals of Bangladesh*: A Field Guide. Nazma Reza, Dhaka, Bangladesh. pp.92.

Kingdom, J. 1977. *East African mammals. An atlas of evolution in Africa. Volume IIIA (Carnivores)*. Academic Press, London, UK. P. 19-24

Korstjens, A.H., Lehmann, J. and Dunbar, R.I.M. 2010. Resting time as an ecological constraint on primate biogeography. *Animal Behaviour*. 79(2), pp.361-374.

Kosintsev, P.A., Tiunov, M.P., Gimranov, D.O. and Panov, V.S. 2016. November. The first finding of Asian black bear (Carnivora, Ursidae, Ursus (Euarctos) thibetanus G. Cuvier, 1823) in the Late Pleistocene of northern Eurasia. In *Doklady Biological Sciences*. Vol. 471, No. 1, pp. 266-268.

Lariviere, S. 2001. "Ursus americanus". *Mammalian Species*. 647: 1–11. *doi:10.1644/1545-1410(2001)647<0001:UA>2.0.CO;2*

Lambertucci, S.A., Carrete, M., Speziale, K.L., Hiraldo, F. and Donazar, J.A. 2013. Population sex ratios: another consideration in the reintroduction - reinforcement debate? *PLOS One*. 2013 Sep 26. 8(9): e75821. doi: 10.1371/journal.pone.0075821. PMID: 24086641; PMCID: PMC3784389

Lanszki, J. and M. Heltai. 2002. Feeding habits of golden jackal and red fox in south-western Hungry during winter and spring. *Mammalian Biology*. 67(3): 129-136.

Lan, C., Liu, Z., Wang, A., Zheng, J., Liu, Q. and Xia, J. 2011. Behavior rhythm and seasonal variation of time budget of sun bear(Helarctos malayanus) in captivity. *Shengtai Xuebao/Acta Ecologica Sinica, 31*(16). pp.4689-4698.

Lapini, L. 2009. Lo sciacallo dorato Canis aureus moreoticus (I. Geoffrey Saint Hilaire, 1835) nell'Italia nordorientale (Carnivora: Canidae) (PDF) (in Italian). V. Ord., relatore E. Pizzul, Fac. Di Scienze Naturali dell'Univ. di Trieste. *Tesi di Laurea in Zoologia*. pp. 1–118.

Leighton, D.R. 1987. Gibbons: territoriality and monogamy. *In*: Smuts, B.B., Cheney, D.L., Seyfarth, R.M., Wrangham, R.W. and Struhsaker, T.T. (eds.). *Primate societies*. Chicago: University of Chicago Press. P. 135–145.

Leutenegger, W. and Cheverud, J. 1982. Correlates of sexual dimorphism in primates: ecological and size variables. *International Journal of Primatology*. 3(4). 387. https://doi.org/10.1007/BF02693740

Linnaeus, C., 1758. Systema Naturae per Raegna Tria Naturae. Vol. 1. Regnum Animale. Trustees. *British Museum (Natural History), London.*

Lambertucci, S.A, Carrete, M., Speziale, K.L., Hiraldo, F. and Donazar, J.A. 2013. Population sex ratios: another consideration in the reintroduction - reinforcement debate? *PLOS One*. 2013 Sep 26. 8(9): e75821. doi: 10.1371/journal.pone.0075821. PMID: 24086641; PMCID: PMC3784389

Lanszki, J. and Heltai, M. 2002. Feeding habits of golden jackal and red fox in south-western Hungry during winter and spring. *Mammalian Biology*. 67(3): 129-136.

Laura, E.T. 2008. Biological information on the Asiatic Black Bear. Michigan State University College of Law.

Leighton, D.R. 1987. Gibbons: territoriality and monogamy. *In*: Smuts, B.B., Cheney, D.L., Seyfarth, R.M., Wrangham, R.W. and Struhsaker, T.T. (eds.). *Primate societies*. Chicago: University of Chicago Press. 135–145.

Leutenegger, W. and Cheverud, J. 1982. Correlates of sexual dimorphism in primates: ecological and size variables. *International Journal of Primatology*. 3(4). p. 387.

Linnaeus, C. 1758. Systema naturae (in Latin). Regnum Animale (10 ed.). *Laurentius Salvius: Holmiae* . pp. 39–40. Retrieved September 18, 2017.

Lorenzo, S. 2009. Husbandry Manual for the Brown Bear (*Ursus arctos*). TAFE NSW- Richmond college, Australia.

Macdonald, D. 2001. The New Encyclopedia of Mammals. Oxford University Press, Oxford. ISBN 0198508239.

Macdonald, D.W. 1979. The Flexible Social System of the Golden Jackal, Canis aureus. *Behaviour. Ecol.Socio-biol*. 5: 17-38.

Mahmood, T., Niazi, F. and Nadeem, M.S. 2013. Diet composition of Asiatic Jackal (Canis aureus) in margallah hills national park, Islamabad, Pakistan. *Journal of Animal and Plant Sciences*.23. pp. 444-456.

Mandl, I., Holderied, M. and Schwitzer, C. 2018. The effects of climate seasonality on behavior and sleeping site choice in Sahamalaza sportive lemurs, Lepilemur sahamalaza. *International journal of primatology*. 39(6). pp.1039-1067.

Martin, P. and Bateson, P. 1995. Measuring Behaviour: An introductory guide. Cambridge University Press.

Masi, S., Mundry, R., Ortmann, S., Cipolletta, C., Boitani, L. and Robbins, M.M. 2015. The influence of seasonal frugivory on nutrient and energy intake in wild western gorillas. *PlOS one*. 10(7). p. e0129254.

Mason, G.J. and Latham, N.R. 2004. Can't stop, won't stop: Is stereotypy a reliable animal welfare indicator? *Animal Welfare*. 13. 57–69.

McFarland, R., Fuller, A., Hetem, R.S., Mitchell, D., Maloney, S.K., Henzi, S.P. and Barrett, L. 2015. Social integration confers thermal benefits in a gregarious primate. *Journal of Animal Ecology*. 84(3). pp.871-878.

McLellan, M.L. and McLellan, B.N. 2015. Effect of season and high ambient temperature on activity levels and patterns of grizzly bears (Ursus arctos). *PLOS One*. 10(2). P. e0117734.

McPhee, M.E. and Carlstead, K. 2010. The importance of maintaining natural behaviors in captive mammals. *Wild mammals in captivity: Principles and techniques for zoo management*. 2. pp. 303-313.

McPhee, M.E. 2002. Intact Carcasses as Enrichment for Large Felids: Effects on On- and Off-Exhibit behaviors. *Zoo Biology*. 21: 37–47.

Melfi, V. and Marples, N. 2000. How different captive environments affect the behaviour of Sulawesi crested blackmacaques. 2nd Annual Symposium of Zoo Research. pp. 151–157.

Meyers, D.M. and Wright, P.C. 1993. Resource tracking: food availability and Propithecus seasonal reproduction. In *Lemur social systems and their ecological basis*. pp. 179-192. Springer, Boston, MA.

Moehlman, P.D. 1983. Socioecology of silverbacked and golden jackals (*Canis mesomelas* and *Canis aureus*) *In*: Eisenberg, J.F. and Kleiman, D.G. (eds.). *Recent advances in the study of mammalian behaviour. American Society of Mammologists Spec*. Publ. No. 7, Pittsburgh Pennsylvania, USA. p. 423-453.

Morelle, R. 2016. World wildlife populations' fall by 58% in 40 years'. BBC NEWS. 27th October. [Accessesd on 24th July 2019]

Morimura, N. and Ueno, Y. 1999. Influences on the feeding behavior of three mammals in the Maruyama Zoo: Bears, elephants, and chimpanzees. *Journal of Applied Animal Welfare Science*, *2*(3). pp.169-186.

Mukherjee, R.P. 1986. The ecology of the Hoolock Gibbon, *H. hoolock*, in Tripura, India. In: Else, J.G. & Lee, P.C. (eds.), *Primate Ecology and conservation*, Cambridge University Press, Cambridge and London. pp. 115-123.

Mukul, S.A., Biswas, S.R. and Manzoor, A.Z.M. 2017. *Biodiversity of Bangladesh*. Preprints. doi: 10.20944/preprints201702.0045.v1

Muzaffar, S. B., Islam, M.A., Feeroz, M.M., Kabir, M., Begum, S., Mahmud, M.S., Chakma, S. and Hasan, M.K. 2007. Habitat characteristics of the endangered hoolock gibbons of Bangladesh: the role of plant species richness. *Biotropica.* 39: 539–545.

Neha, S.A., Khatun, M.U.H. and Hasan, M.A.U. 2020. Feeding Behavior of the Western Hoolock Gibbon (*Hoolock hoolock*) in Bangladesh: Response to Temporal Variation of Food Sources. *Primate Conservation*. 34. 185-194.

Nielsen, E. T. 1983. Relation of behavioral activ-ity rhythms to the changes of day and night: A revi-sion of views. Behaviour, 89, 147-173. http://dx.doi.org/10.1163/156853984X00083

Oates, J. F. 1987. Food distribution and foraging behaviour. In: Primate Societies (B. B. Smuts et al., eds.). *Chicago and London: The University of Chicago Press*. pp. 197–209

Poche, R.M., Evans, S.J., Sultana, P., Hague, M.E., Sterner, R. and Siddique, M.A. 1987. Notes on the golden jackal (Canis aureus) in Bangladesh. *Mammalia*. 51(2). pp. 259-270.

Prater, S.H. 1980. *The book of Indian animals*. Bombay Natural History Society. Oxford University Press. Bombay, India.

Raichev, E., Peeva, S., Masuda, R., Kaneko, Y., Tsunoda, H., Georgiev, D. and Georgiev, D. 2017. Sexual dimorphism in body parameters of the golden jackal Canis aureus L., 1758 (Carnivora, Canidae) in the Sarnena Sredna Gora Mountain and Thracian plain (Bulgaria). *Trakia Journal of Sciences*.15(2). p.135.

Reichard, U. and Barelli, C. 2008. Life history and reproductive strategies of Khao Yai Hylobates lar: implications for social evolution in apes. *International Journal of Primatology*. 29: 823–844.

Reid, G.M.C.G., Macdonald, A.A., Fidgett, A.L., Hiddinga, B. and Leus, K. 2008. *Developing the research potential of zoos and aquaria. The EAZA Research Strategy*. EAZA Executive Office, Amsterdam.

Reinhardt, V. and smith, M.D. 1988. PVC pipes effectively enrich the environment of caged rhesus macaques. *Laboratory Primate Newsletter*. 27(3): 4–5.

Rija, A.A., Kideghesho, J.R., Mwamende, K.A. and Selemani, I. 2013. Emerging issues and challenges in conservation of biodiversity in the rangelands of Tanzania.

Roberts, T.J. 1977. The Mammals of Pakistan, Ernest Benn. *The Mammals of Pakistan, London, 26*, p. 361.

Roberts, T.J. 1997. *The Mammals of Pakistan*. Revised edition. Oxford University Press, Karachi, Pakistan. pp. 525.

Rosevear DR. 1974. Cheetah. In: Rosevear DR, editor. The Carnivores of West Africa. London: Trustees of the British Museum (Natural History). Pp. 492-512.

Roubova, V., Konecna, M., Smilauer, P. and Wallner, B. 2015. Whom to Groom and for What? Patterns of Grooming in Female Barbary Macaques (Macaca sylvanus)". *PLOS ONE*. 10 (2):e0117298. Bibcode:2015PLoSO.1017298R. doi:10.1371/journal.pone.01172 98. PMC 4323340. PMID 25668722

Rounds, R.C. 1987. Distribution and analysis of colour morphs of the black bear (Ursus americanus). *Journal of Biogeography*. 14: 521–438.

Ryder, O.A. and Feistner, A.T. 1995. Research in zoos: a growth area in conservation. *Biodiversity & Conservation*. 4(6). 671-677.

Sarkar, M.S.U. 2006. The status and conservation of bears in Bangladesh. *Understanding Asian bears to secure their future. Japan Bear Network,Ibaraki, Japan*. pp. 41–44.

Sathyakumar, S. 2001. Status and Management of Asiatic Black Bear and Himalayan Brown Bear in India. *Ursus*, 12, 21-29. Retrieved December 10, 2020, from http://www.jstor.org/stable/3873225

Schaller, G.B., Qitao, T., Johnson, K. G., Xiaoming, W., Heming, S. and Jinchu, H. 1989. The Feeding Ecology of Giant Pandas and Asiatic Black Bears in the Tangjiahe Reserve, China. *In*: Gittleman, J. L. (ed.). pp. 212-241 *Carnivore Behavior, Ecology, and Evolution.* Springer US.

Schino, G. 2001. Grooming, competition and social rank among female primates: a meta-analysis. *Animal Behaviour*. 62(2): 265–271. doi:10.1006/anbe.2001.1750. S2CID 53145237

Schultz, A.H. 1973. The skeleton of the Hylobatidae and other observations on their morphology. *Gibbon and Siamang*. Karger, Basel. *2*. 1-54.

Schwitzer, C. and Kaumanns, W. 2003. Foraging patterns of free-ranging and captive primates-implications for captive feeding regimes. Zoo Animal Nutrition II. Filander Verlag, pp.247-265.

Sergiel, A., Naves, J., Kujawski, P., Maślak, R., Serwa, E., Ramos, D., Fernández-Gil, A., Revilla, E., Zwijacz-Kozica, T., Zięba, F. and Painer, J. 2017. Histological, chemical and behavioural evidence of pedal communication in brown bears. *Scientific reports*. *7*(1). pp. 1-10.

Servheen, C., Herrero, S. and Peyton, B. 1999. Bears: Status Survey and Conservation Action Plan. IUCN, Gland.

Shariful, 2018. Bangladesh National Zoo map, own work. https://images.app.goo.gl/cAZZbRMeArkGeRD99. Downloaded on 9-10-2020.

Sheldon, J.W. 1992. *Wild dogs: the natural history of the non-domestic Canidae*. Academic Press, Chicago, IL, USA.

Shire, T.E.E. 2012. *Differences in behavior between captive and wild ring-tailed lemur (Lemur catta) populations: Implications for reintroductions and captive management.* Iowa State University.

Sillero-Zubiri, C., Hoffmann, M. and Macdonald, D.W. (eds.). 2004. *Canids: foxes, wolves, jackals, and dogs: status survey and conservation action plan.* Gland, Switzerland: IUCN. 156-161.

Singh, A., Mukherjee, A., Dookia, S. and Kumara, H.N. 2016. High resource availability and lack of competition have increased population of a meso-carnivore—a case study of golden jackal in Keoladeo National Park, India. *Mammal Research.* 61(3). pp. 209-219.

Stan, F. 2016. Morphological particularities of the teeth crown in golden jackal (*Canis aureus moreoticus*). *Scientific Works. Series C. Veterinary Medicine. 62*(2). pp. 44-51.

Stanford, C.B., 1991. *The capped langur in Bangladesh: behavioral ecology and reproductive tactics* (Vol. 26). Karger Medical and Scientific Publishers.

Stelzner, J. K. 1988. Thermal effects on movement patterns of yellow Baboons. *Primates.* 29, 91–105.

Stirling, I., Kirshner, D. and Knight, F. 1993. *Bears, Majestic Creatures of the Wild.* Emmaus: Rodale Press.

Stubblefield, C.H. and Shrestha, M. 2007. Status of Asiatic black bears in protected areas of Nepal and the effects of political turmoil. *Ursus. 18*(1). pp.101-108.

Swanson, S.A. 1990. Activities and habitat use of black bears in north-central Minnesota. MSc thesis, University of Minnesota, Minneapolis, MN.

Swin, N.S. 2015. *Dhaka Palte Jatio Chiriakhana. In*: banglanews24.com, 2138 hr, 11 February, 2015. https://www.banglanews24.com/national/news/bd/366660.details. Downloaded at 14-12-2020.

Tiddi, B., Aureli, F. and Schino, G. 2012. Grooming up the hierarchy: the exchange of grooming and rank-related benefits in a new world primate. *PlOS ONE.* 7(5). p. e36641.

Temperature-Dhaka, Bangladesh 2020. https://images.app.goo.gl/MD97NWwACHAM5whS6. Dowmloaded on 12-11-2020.

Vaughan, T.A., Ryan, J.M. and Czaplewski, N.J. 2000. *Mammmalogy.* Fourth Edition. Saunders College Publishing, Philadelphia. pp. vii+ 565.

Veasey, J.S., Waran, N.K. and Young, R.J. 1996. On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator. *Animal Welfare*. 5. 13–24.

Vereecke, E.E. and Aerts, P. 2008. The mechanics of the gibbon foot and its potential for elastic energy storage during bipedalism. *The Journal of Experimental Biology*. 211: 3661–3670.

Walker, S., Molur, S. and Brockelman, W.Y. 2007. Western hoolock gibbon, *Hoolock hoolock* (Harlan, 1831). *Primate Conservation*. 22: 1–18.

Wallis, L.J. 2019. Canine life history. Encyclopedia of animal cognition and behavior, pp.1-17.

Weigl, R. 2005. *Longevity of Mammals in Captivity; from the Living Collections of the World. Schweizerbart Science Publishers*. 48: 214.

Williams, E., Carter, A., Hall, C. and Bremner-Harrison, S. 2019. Social interactions in zoo-housed elephants: Factors affecting social relationships. *Animals*. 9(10). p.747.

WrightJr, K.P. 2009. Seasonal Changes in Night-Length and Impact on Human Sleep. Encyclopedia of Neuroscience.

Wyman, J. 1967. The jackals of the Serengeti. *Animals*. 10: 79-83.

Yadav, V.K., Chauhan, DS. and Lakhera, PC. 2019. Occurrence and feeding habit of Asiatic black bear (Ursus thibetanus) in Nanda Devi biosphere reserve, Uttarakhand, India. Journal of Entomology and Zoology Studies. 7(3): 1650-1656.

Zarzo-Arias, A., Delgado, M.M., Ordiz, A., Díaz, J.G., Cañedo, D., González, M.A., Romo, C., García, P.V., Bombieri, G., Bettega, C. and Russo, L.F., 2018. Brown bear behaviour in human-modified landscapes: The case of the endangered Cantabrian population, NW Spain. *Global Ecology and Conservation*. 16. p. e00499.

Appendices

APPENDICES

Appendix-I Overall time spent of activity pattern by Western Hoolock Gibbon, Asiatic Black Bear and Asiatic Jackal.

Behaviour	Hoolock Gibbon % of time spent	Asiatic Bear % of time spent	Asiatic Jackal % of time spent
Feeding	12.42%	16.50%	12.52%
Resting	40.54%	55.63%	15.43%
Moving	17.79%	11.55%	29.29%
Grooming	5.02%	3.42%	-
Playing	6.84%	-	-
others	17%	12.90%	42.76%

Appendix-II Monthly variation in time spent (Western Hoolock Gibbon).

Month	Feeding	Resting	Moving	Grooming
January	20.3%	28.2%	25.2%	24.7%
February	26.2%	21.7%	23.9%	22.8%
March	20.8%	30.6%	21.9%	26.8%
April	23.3%	26.4%	29.5%	20.2%
May	31.5%	18.3%	25.1%	24.7%
June	24.5%	24.9%	23.7%	28.5%
July	28.3%	23.8%	24.7%	25.6%
August	24.5%	31.8%	21.2%	28.5%
September	25.5%	22.9%	26.9%	23.0%
October	21.8%	21.7%	27.4%	23.1%
November	28.8%	24.4%	26.4%	23.1%
Decembr	24.9%	25.9%	24.6%	29.4%

Appendix-III Monthly variation in time spent in different behaviour (Asiatic Black Bear).

Month	Feeding	Resting	Moving	Grooming
January	27.0%	28.3%	21.2%	26.8%
February	18.0%	20.5%	27.8%	23.5%
March	29.3%	27.8%	21.8%	25.2%
April	28.3%	25.8%	25.0%	29.2%
May	17.3%	19.3%	30.5%	24.4%
June	26.3%	27.3%	22.8%	21.3%
July	25.5%	23.5%	22.3%	20.2%
August	27.3%	26.5%	27.8%	26.3%
September	22.5%	25.3%	25.5%	28.2%
October	24.8%	24.8%	24.5%	25.4%
November	24.0%	21.8%	28.9%	24.5%
Decembr	31.0%	29.5%	22.3%	25.3%

Appendix- IV Monthly variation in time spent in different behaviour (Asiatic Jackal).

Month	Feeding	Resting	Moving
January	27.0%	28.3%	21.2%
February	18.0%	20.5%	27.8%
March	29.3%	27.8%	21.8%
April	28.3%	25.8%	25.0%
May	17.3%	19.3%	30.5%
June	26.3%	27.3%	22.8%
July	25.5%	23.5%	22.3%
August	27.3%	26.5%	27.8%
September	22.5%	25.3%	25.5%
October	24.8%	24.8%	24.5%
November	24.0%	21.8%	28.9%
Decembr	31.0%	29.5%	22.3%

Appendix-V Seasonal variation in time spent in different behaviour (Western Hoolock Gibbon).

Behaviour	**Summer**	**Rainy**	**Winter**
Feeding	38.32%	34.22%	27.45%
Resting	26.28%	38.03%	35.69%
Moving	37.66%	29.00%	33.33%
Grooming	22.22%	34.65%	43.13%
Playing	38.64%	29.32%	32.07%

Appendix-VI Seasonal variation in time spent in different behaviour (Asiatic Black Bear).

Behaviour	**Summer**	**Rainy**	**Winter**
Feeding	28.33%	33.34%	38.33%
Resting	29.33%	33.33%	37.34%
Moving	38.00%	28.66%	26.78%
Grooming	43.30%	26.78%	29.91%

Appendix-VII Seasonal variation in time spent in different behaviour (Asiatic Jackal).

Behaviour	**Summer**	**Rainy**	**Winter**
Feeding	30.34%	33.32%	36.32%
Resting	33.33%	29.34%	37.33%
Moving	33.33%	38.33%	28.33%

Appendix-VIII Provisioned foods given to the Hoolock Gibbon, Asiatic Black Bear, Asiatic Jackal.

Western Hoolock Gibbon		**Asiatic Black Bear**		**Asiatic Jackal**	
Food item	**Quantity of food**	**Food item**	**Quantity of food**	**Food item**	**Quantity of food**
Banana (*Musasp.)*	250gm	Milk	1.5 kg.	Meat (Mon-Saturday)	1-2kg
Apple *(Malus domestica)*	125gm.	Rice	0.5kg		
Sweet orange (*Citrus maxima)*	125gm.	Banana (*Musasp.)*	1 kg.	Chicken (Sunday)	1-2kg
Orange *(Citrus reitculata)*	125gm.	Sweet orange (*Citrus maxima)*	0.5kg.		
Sapodilla (*Manilkara zapota)*	125gm.	Mango (*Mangifera indica)*	1.5kg.		
papaya *(Carica papaya)*	125gm.	Apple *(Malus domestica)*	1 kg.		

Litchi (*Litchi chinensi)*	150gm.	pumpkin *(* Cucurbita maxima)	1 kg.		
Grape *(Vitis vinifera)*	125gm.	Nut	0.25 kg.		
Date *(Phoenix dactylifera*)	50gm.	Honey	0.1 kg.		
Cucumber *(Cucumis sativus)*	500gm.	Bread	1 kg.		
Boiled egg	1piece.	Cucumber *(Cucumis sativus)*	1 kg.		
		Boiled egg	0.25 kg.		

Appendix-IX t -test between the feeding of adult and sub adult Hoolock Gibbon.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Feeding	Equal variances assumed	.234	.634	-.028	22	.978	-.01667	.58550	-1.23092	1.19759
	Equal variances not assumed			-.028	21.258	.978	-.01667	.58550	-1.23338	1.20005

Appendix-X t -test between the moving of adult and sub adult Hoolock Gibbon.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Moving	Equal variances assumed	1.618	.217	-.609	22	.549	-2.83000	4.64906	-12.47156	6.81156
	Equal variances not assumed			-.609	21.326	.549	-2.83000	4.64906	-12.48926	6.82926

Appendix-XI Result of ANOVA for the variation of diurnal feeding variation of Asiatic Black Bear.

ANOVA

Feeding

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52885.132	2	26442.566	8207.448	.000
Within Groups	106.319	33	3.222		
Total	52991.451	35			

Appendix-XII Result of ANOVA for the variation of diurnal resting variation of Asiatic Black Bear.

ANOVA

Resting

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16618.907	2	8309.454	1127.439	.000
Within Groups	243.217	33	7.370		
Total	16862.124	35			

Appendix-XIII Result of ANOVA for the seasonal variation of feeding of Asiatic Jackal.

ANOVA

Feeding

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	76.350	2	38.175	8.796	.003
Within Groups	65.101	15	4.340		
Total	141.451	17			

Appendix-XIV Result of ANOVA for the seasonal variation of moving of Asiatic Jackal.

ANOVA

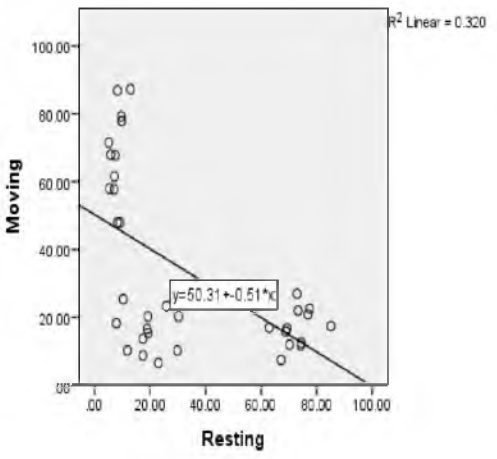
Moving

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	216.899	2	108.449	12.609	.001
Within Groups	129.010	15	8.601		
Total	345.909	17			

Appendix-XV Result of Correlation between the moving and resting of Western Hoolock Gibbon.

Correlations

		Resting	Moving
Resting	Pearson Correlation	1	-.566**
	Sig. (2-tailed)		.000
	N	36	36
Moving	Pearson Correlation	-.566**	1
	Sig. (2-tailed)	.000	
	N	36	36



Appendix-XVI Result of Correlation between the moving and resting of Asiatic Black Bear

Correlations

		Resting	Moving
Resting	Pearson Correlation	1	-.976**
	Sig. (2-tailed)		.000
	N	36	36
Moving	Pearson Correlation	-.976**	1
	Sig. (2-tailed)	.000	
	N	36	36