

REPRODUCTIVE BEHAVIOR OF RED PANDA *Ailurus fulgens* IN
THE CENTRAL ZOO, LALITPUR, NEPAL



Entry 3

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Submitted to

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Nepal

September 2022

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award for any degree. All sources of information have been specifically acknowledged by reference to author(s) or institution(s).

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CERTIFICATE OF ACCEPTANCE

The thesis work submitted by Ms. Heena Maharjan entitled “**Reproductive behavior of Red Panda *Ailurus Fulgens* in the Central Zoo, Lalitpur, Nepal**” has been accepted as partial fulfillment for the requirements of the degree of Master of Science in Zoology with special paper Ecology and Environment.

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ABSTRACT

The population of Red Panda is decreasing with less than 10,000 individuals in the wild because of habitat destruction, fragmentation, poaching, and hunting for its fur. Captive breeding has become an increasingly crucial strategy for conserving such endangered species, but efforts to generate self-sustaining populations have met with poor success despite large resources being allocated. Animals are also known to be stressed in captivity and it is necessary to examine reproductive behavior in relation to the complexity of habitat requirements, dietary preferences, privacy, and, in particular, pregnant moms and their sensitivity to disruptions. This study observed the reproductive behavior of the Red Panda along with other behavioral activities in the Central Zoo, Lalitpur, Nepal using the non-invasive videography method. Scan and focal sampling were used to collect the behavioral data from December 2020 to June 2021. A total of 16,416 behavioral activities were recorded in 20,520 minutes. The reproductive behaviors scent-marking, allogrooming, chasing, running, aggressiveness, sniffing, response, mating and feeding on feces were observed along with the general behaviors like locomotion, climbing, standing, self-grooming, resting, feeding, sleeping, defecation, urination, drinking, self-play, and stretching. The study revealed that reproductive behavior covered only 1-2% of the total activity budget. Precipitation influenced the reproductive behavior, and activities increased at low volume of precipitation. Humidity and atmospheric pressure had no significant effect. Copulation was attempted many times, and hence, reproduction can be successful if the animal husbandry is properly managed.

1. INTRODUCTION

1.1 Background

Conservation of carnivore species has become a challenge as human intrusions and disturbance leading to modification in natural systems, habitat loss and fragmentation, climate change, invasive species, and diseases are imperiling the wildlife species at increasingly rapid rates (Wei et al. 1999, Marneweck et al. 2021). Illegal hunting and poaching are also driving a lot of strain on carnivores all around the world to supply the illicit wildlife trade (Willcox 2020). Carnivores are also perceived as threats and people have a negative attitude toward them (Slof Pacilio 2020). The protection of carnivores is also extremely difficult as they need a large home range and a sustainable prey population, and mitigating or lowering threats in their natural habitat seems a significant challenge to cope with the rapidly declining numbers (Balme et al. 2014). Many endangered carnivore species are protected under the protected area system, however, the majority of them are in nations with weak governments and high levels of corruption, making them nothing more than "paper parks" (Pedrono et al. 2009, Willcox 2020). Hence, these species are one of the most fragile living organisms in diversity.

The Red List of Threatened Species published by the International Union for Conservation of Nature has enlisted Red Panda as one of the globally endangered carnivore species (Glatston et al. 2015). Red Panda is a cryptic species, found in sub-tropical and temperate alpine forests in the Himalayas and southern China (Roberts and Gittleman 1984, Yonzon 1989, Yonzon and Hunter 1991, Sharma and Belant 2009, Glatston et al. 2015). The Red Panda has two sub-species *A. f. fulgens* and *A. f. styani* by Nujiang River in Yunnan, China with *A. f. fulgens* distributed in Bhutan, India, and Nepal, and *A. f. styani* in Sichuan and a small portion of Yunnan and Myanmar (Wei et al. 1999, Choudhury 2001, Groves 2011, Dorji et al. 2012). Recently, Hu et al. (2020) claimed that these two sub-species are separate species as Himalayan Red Panda and Chinese Red Panda. The Red Panda is a bamboo specialist species although being classified as a carnivore whose more than 90% diet consists of bamboo with opportunistic ingestion of fruits, leaves, eggs, insects, small birds, mushrooms, and various grasses (Yonzon and Hunter 1991, Wei et al. 1999, Pradhan et al. 2001, Dorji et al. 2012, Sharma et al. 2014b).

Major difficulties confronting the species include expanding infrastructure development, habitat loss and degradation, poaching, forest fire, and potential disease transmission from

sympatric livestock (Thapa et al. 2018, Bista et al. 2020, Sharma and Achhami 2022), and a lack of knowledge about the species, particularly the failure of locals to recognize Red Pandas (Dorji et al. 2012). The Red Panda population is declining throughout its range, with probably < 10,000 individuals in the wild (Glatston et al. 2015). The breeding success of Red Panda in the wild seems low, also due to their isolated population, and high mortality of cubs (Yonzon 1989). To minimize this problem, many European and Asian zoos established captive breeding and developed strategies to release them in the wild (*See* India: Himalayan Zoological Park in Gangtok and Padmaja Naidu Himalayan Zoological Park), as well as to distribute them to other zoos. The first Red Panda in zoo was first introduced in the London Zoo in 1869 (Jones 2022). However, the survival rate and breeding success were reported since 1985 after the initiation of the European Endangered Species Programme (Kappelhof and Weerman 2020). The success of captive breeding of Red Pandas can support their demand in zoos and will minimize its dependency on wild ones. However, the reproductive success of the species in captivity will be based on the captive environment and their behavior.

Field studies on Red Pandas behavior have been inconsistent and scarce (Yonzon and Hunter 1991, Glatston et al. 2015) because of their remote geographic locations and fragmented populations across multiple countries, as well as their arboreal and nocturnal natures (Roberts and Gittleman 1984, Johnson et al. 1988, Glatston et al. 2015) and some of their ecology and behavior is also studied using captive populations. Red Pandas demonstrated a wide range of behaviors including self-scratching, lying-sleeping, scent-marking, exploring, carrying objects, and aggressiveness, as well as certain typical behaviors such as foraging, feeding, self-play, vocalization, and climbing (Roberts and Gittleman 1984, Andres-Bray et al. 2020). During the arrival of the breeding season between December to late March, the proximity between male and female increases with the display of reproductive behavior like frequent scent-marking, copulation after mount invitation by female, clasping, licking, ejaculation, and genital auto-grooming (Roberts and Gittleman 1984). Pregnant females start nest-building which is continued even after birth yet, they may accept nest boxes in captivity and maternal behavior showcase includes licking and cleaning after parturition, nursing, grooming, and contact call “twitter” within cubs and adults (Roberts and Gittleman 1984, Dechanupong 2019).

Ex-situ conservation breeding programs are becoming popular among conservation managers as a means of preventing species extinction and/or restoring natural populations

(Ramirez et al. 2006, Conde et al. 2011). Unfortunately, ex-situ conservation is not always an easy technique to save a threatened species (Kiik et al. 2013). It is not only expensive but capturing wild animals, transporting them to artificial surroundings, and controlling them in captivity, with all of the new interactions with their environment and conspecifics, are all stressful experiences for the animals (Kathleen and Tomborg 2007). Similarly, animals in captivity have no control over their surroundings and have no opportunity to escape any undesirable situations (Kathleen and Tomborg 2007, Kiik et al. 2013). Captive animals have less opportunity to express their typical behavior, which causes them to display more rigid and repetitive behavior (Vanhoomissen 2016). The longevity of these charismatic species is also comparatively lower in captivity than in natural conditions (Roberts and Gittleman 1984) which automatically lowers breeding chances. Red Pandas are sensitive animals and one can assume that without sufficient chance to escape from the sight of visitors and helplessness in captivity might cause chronic stress, affecting the immune system and reproductive capability (Loeffler 2011). The understanding of reproductive behavior relating to the complexity of its habitat requirement, preference of food, privacy, especially of mothers in gestation period and sensitivity to disturbances are lacking and the study is an urgent need in order to achieve remarkable life span increment and breeding success in captivity (Andres-Bray et al. 2020). Hence, successful and cost-effective breeding programs rely largely on the development of behavioral management strategies driven by the application of scientific knowledge (Zhang et al. 2004, Martin-Wintle et al. 2017). It would be highly helpful to investigate in-depth reproductive behavior in captivity for endangered species to successfully reproduce, while considering both the biology of the species and characteristics of their captive habitat. Conservationists can further use this information for the establishment or improvement of the captive management plan.

1.2 Objectives

1.2.1 General objective

The general objective of this study was to identify the reproductive and other behavioral activities of the Red Panda and promote captive breeding in the Central Zoo of Nepal.

1.2.2 Specific objective

- i. To analyze the reproductive and non-reproductive behavior of the male and the female Red Pandas in the Central Zoo.

- ii. To identify the factors affecting the reproductive behaviors of the Red Pandas in the Central Zoo.

1.3 Rationale of the study

Behavior is the action of the organism as a result of external factors (threat, temperature, interaction) and internal factors (hunger, fear). Animal behavior gives the knowledge of the physiology, anatomy, and psychology of an animal (Hill and Broom 2009). It helps to understand the influence of genes and the environment. The behavioral study is important to formulate proper strategies for the conservation of the organism both in their natural habitat and in captivity. Additionally, reproductive behavior study gives the insight to understand the overall biology of an organism to increase its life span, fertility rates, and reduce mortality rates. In a broader sense, such studies contribute to the conservation of species (Leus 2011). The exhibition of Red Pandas in the Central Zoo serves as an attraction to many visitors. However, the zoo is restricted to capture/or collect them from their natural habitats whenever required as they are endangered (Glatston 1989). This highlights the need of maintaining the survivorship of these species along with the emphasis on the rise of individual numbers through breeding. Captive colonies can potentially act as a source of future reinforcements for their own species in the wild (Ramirez et al. 2006). Red Pandas are capable of giving birth to an average of two cubs per litter but this seems challenging to achieve as of now. Researches in the behavioral study are important to attain the expected reproductive success. Understanding the behavioral needs can help us design better enclosures, provide preferred food with adequate nutrition, management of social grouping, hand-rearing of cubs, and even provide medicinal services timely (Andres-Bray et al. 2020). Hence, the behavioral studies of such endangered species are a current need in the conservation of living populations and increasing the number of individuals by maximizing breeding success.

2. LITERATURE REVIEW

2.1 Red panda: Status and Ecology

The Red Panda is the sole member species of the family Ailuridae (Glatston et al. 2015). The sub-species of Red Pandas: *Ailurus fulgens fulgens*, which lives in western Bhutan, Nepal, India, northern Myanmar, and northern China, possesses darker coat, more noticeable tail stripes, a bigger head, and a more rounded frontal bone compared to the sub-species *A. f. styani*, which are native to central and southern China (Roberts and Gittleman 1984). These sub-species are generally found in the elevation of 2,200 – 4,800 m above sea level (Choudhury 2001, Dorji et al. 2011) well acclimated to the regions where the temperature usually doesn't exceed over 20°C (Roberts and Gittleman 1984). They are well adapted to this environment and has adaptational features like dense fur coat, bushy tail, and low metabolic rates (Yonzon and Hunter 1991). Red Pandas are arboreal in nature and spend majority of their time budget on sleeping and resting in canopy-covered trees and logs (Dorji et al. 2012). Hence, these species require fallen logs and trees in their habitat for resting, foraging, defecation, and mobility between trees along with the areas about 100 m near the water resources (Bhatta et al. 2014, Sharma et al. 2014a).

Although the accurate number of Red Pandas in the wild is unknown, it is speculated that there are less than 10,000 of them in existence (Glatston et al. 2015). Out of which 500 to 1,100 individuals are distributed in India and Nepal, 3,000 to 7,000 in China, and an undetermined number in Bhutan and Myanmar (Wei et al. 1999, Chakraborty et al. 2015, Glatston et al. 2015, Princee and Glatston 2016). This number is not sustainable due to a decline of around 50% of their population over the last 18 years, and it is expected that the reduction in their count will continue over the next three decades (Dorji et al. 2012) making them vulnerable. Deforestation-related habitat loss for Red Pandas is the primary factor contributing to the population reduction in addition to fragmentation making these specialized feeders harder to find their food sources and preferred habitat (Groves 2011, Leus 2011, Glatston et al. 2015).

2.2 History of Red Panda in Captivity

Red Pandas are often used as a flagship species for generating awareness and stimulating conservation efforts for themselves and similar animals and their habitat. These species have long served as a medium of attraction in captivity. The first Red Panda in the zoo was introduced in the London Zoo in 1869 and in the United States, these species initially

arrived at the Philadelphia Zoo in 1906 (Jones 2022). However, the successful breeding was achieved only in the 1940s at the San Diego Zoo (Jones 2022). This success was achieved from the three female and a male Red Panda, all housed together in the same cage.

A total of 34 cubs were born in the San Diego Zoo between 1940 and 1949 (Jones 2022). Nine of them (26% infant mortality rate including stillbirths) died within a month, two (5.8%) died as juveniles from canine distemper, six (17.6%) had no known result of death, and the remaining fifty percent lived to adulthood. The cubs that were able to survive were distributed to various zoos across the United States (Jones 2022). Most of the species were housed together in big enclosures during this time. Around 250 *A. f. fulgens* were displayed in zoos across European and North American countries between 1950 and 1969, the majority of these animals being captured from the wild which further produced 35 cubs in total (Loeffler 2011). Since the commencement of the European Endangered Species Programme in 1985, the survival rate and breeding success have been well achieved in the captive conditions for the Red Pandas (Kappelhof and Weerman 2020). However, the captive populations have their own difficulties to tackle with, including maternal cannibalism and less maternal care, pneumonia, and even trauma-related deaths (Delaski et al. 2015).

2.3 Reproductive behaviors of Red Panda

The captive Red Pandas have an average life span of 12 to 15 years (Gittleman 1994). Sexual maturity is obtained at the age of 22 months by both the sexes (Glatston 2021). These animals experience delayed implantation and their gestation period ranges from 90 to 145 days (Gittleman 1994). In captivity, the male and the female activities start to synchronize with the breeding season and they begin to rest, sleep, feed, and move in close proximity carefully responding to each other's behaviors (Roberts and Gittleman 1984). Chemo-communication occurs between the pair by scent-marking (Roberts and Gittleman 1984) as well as through vocalizations (Yonzon and Hunter 1991). Males spent noticeably more time studying the female's tracks, fecal marks, and urine markings (Roberts and Gittleman 1984). Copulation occurs on the ground and usually lasts from 3 – 39 minutes followed by a long period of genital auto grooming (Roberts and Kessler 1979). The female is observed to carry branches and leaves for nest building while also accepting the provided nest boxes in captivity before birth (Gebauer 2022). After birth, the female lowers her activity level spending the most time with the cub. The cubs are generally kept inside the enclosure for 2 to 3 months and completely depend on the mother (Glatston et al. 2015).

3. MATERIALS AND METHODS

3.1 Study area

The Central Zoo of Nepal was established as a private zoo in 1932 by the late Rana Prime Minister Juddha Samsher in Jawalakhel, Kathmandu Valley. After the political upheavals in 1950, it came under the ownership of the Nepal government and has remained open to the public since 1956. In 1995, the management of the zoo was entrusted to National Trust for Nature Conservation for 30 years. The zoo covers six hectares of land providing a home to 1,026 animals of 113 species including ten reptile species, 15 fish species, 50 bird species, and 38 mammal species (Central Zoo; 15 July 2022). The zoo serves as a recreational center for its visitors with a library, children's park, picnic spots, aquarium, and lake for paddle boating. It also comprises the animal hospital with the availability of vaccination, nursery, and quarantine management services, among other animal care and treatment. It is the country's primary facility for the rescue and rehabilitation of animals, as well as a vital source for wildlife relocation. An estimated one million people visit the zoo every year. The zoo aims to generate public awareness and participation of people in nature and wildlife conservation.

3.2 Enclosure space

The enclosure of the Red Panda in the zoo is composed of open space with an attached small one-storied structure with air conditioning. The open space covers an area of 132 m². It is a natural environment covered with a tall Camphor tree *Cinnamomum camphora*, and bamboo plants. The tree consists of an artificial nest box on one of its branches (See Photograph 1). The space is enclosed by walls and visitors can have the sight of Red Pandas from behind the walls.

The man-made structure measures 3.62 m² and is separated into two sections for providing private space for each of the two individuals present there. While each of the pandas has its own room, the rooms are attached and partitioned with about a meter tall walls and lattice iron bars on them. Therefore, subjects were able to see each other, smell, hear each other vocalizations and even have very limited physical contact through the bars with the neighboring animal. Wooden planks and logs have been fixed inside each enclosure along with nest boxes and the space is designed to fit their arboreal nature. The female enclosure even consists of a staircase. This building helps the animals to escape the sight of visitors anytime they want which is essential as these species are solitary in nature and are unlikely

to enjoy crowds. As a part of sanitation maintenance, the floor of the entire structure is cleaned using Kohrsolin and rinsed afterward using clean water every morning.



Photograph 1 Enclosure of Red Panda in the Central Zoo, Nepal (A: Natural space and man-made space from the frontal view, B: Natural space and man-made space from the back view, C: Air-conditioned room inside man-made space and D: Natural space along with artificial nest box).

3.2 Model species

This study includes one mated pair of Red Panda from the Central Zoo (*See* Photograph 2). Red Pandas have arboreal and nocturnal lifestyles and are diet specialist species with bamboo as their major food (Roberts and Gittleman 1984, Yonzon and Hunter 1991, Sharma et al. 2014b). They are solitary species in their natural habitats; normally sighted alone unless it is mating season or when females are rearing offsprings (Yonzon and Hunter 1991, Conrad 2021). The male Red Pandas weigh around 3.7 to 6.2 kg while the females weigh around 4.2 to 6 kg (Roberts and Kessler 1979). Females give birth between 114 and 145 days after conception, with the majority of births taking place in summer months of June and July in the northern hemisphere (Glatston 2021).

The captive Red Panda was first known to be introduced in the London Zoo in 1869 (Jones 2022). The captive pair included in this study of the Central Zoo of Nepal were brought from the Rolpa district of Lumbini Province in 2015. The visual difference between the pair is fur coloration. The male is dark reddish-brown while the female has lighter-colored fur (*see* Photograph 2). The male and female were housed separately at the beginning of the research, and they were permitted periodic access to each other's spaces to become familiarized. However, the animals are always able to establish visual, olfactory, and acoustic communication. The animals were housed together during the entire study period and behavioral observation was carried out.



Photograph 2 The pair of Red Panda housed in the Central Zoo of Nepal (Female in resting and male in walking posture)

3.3 Data collection

All experiments were conducted by using a non-invasive method of videography during the breeding season between 15 December 2020 and 3 June 2021. The experimental site was recorded using a digital video system for data acquisition. Eight closed-circuit cameras were fixed inside and outside the enclosure of Red Panda such that the cameras give full

visibility of the enclosure. These cameras were used to capture the activity of both Red Pandas for 24 hours every day during the study period continuously. Red Panda's breeding season starts at the beginning of December. Therefore, they were given periodic access to each other's enclosure for familiarization from 15 December 2020 and were housed together from 17 December 2020, and all activities before and after copulation for their breeding season (December to June/July) were recorded using video. The video was observed on the computer screen and the data was recorded manually from 15 December 2020 to 3 June 2021.

3.3.1 Behavioral observation

Behavioral observations were carried out on both the male and the female Red Panda by the non-invasive method of videography. An ethogram (Appendix 1) was developed and data was recorded accordingly by the following methods:

i. Scan sampling

Scan sampling is the instantaneous sampling performed in a group (Altmann 1974) where the organisms of the group are observed at the preselected time (e.g., every minute on the minute throughout the day). The behavior of the male and the female Red Panda was observed and recorded at predetermined time intervals. For every fifteen minutes of time duration, individuals were observed and their activity was noted at that instant of time for the entire day during the study period.

ii. Focal sampling

The term "focal-animal sampling" is used to describe the sampling technique in which all instances of specific actions and interactions between an individual or a group are noted during each sample period and a record of time length for each focal individual is noted for the duration during when it is visible (Altmann 1974). In this sampling method, all of the actions of the male and the female Red Pandas were recorded for a specified period in turns separately but for the same time period. The activities were observed in the interval of every two hours for ten minutes starting from 1.00 am to 11.00 pm each day.

3.3.2 Weather data

For each day of the study period, humidity (%), atmospheric pressure (mBar), and daily rainfall volume (mm) were noted from the google weather data (www.weather.com). The quantity of water vapor in the air is known as humidity. High humidity can result in

hyperthermia (overheating) since the body can't release heat as effectively. The weight of the air in the Earth's atmosphere exerts pressure, which results in air pressure. The total daily volume counts the total volume of rain that day.

3.4 Data analysis

Descriptive statistics were calculated to determine the overall activity budget for both male and female Red Pandas. Each behavior was divided by the total value obtained of the behavioral category under which it has been categorized and then converted into percentage. Mann-Whitney U test was used to compare the behavioral differences between the reproductive and the non-reproductive activities between the male and female pandas due to non-parametric data. Statistical significance was assessed at $p < 0.05$.

The effect of humidity, atmospheric pressure, and daily precipitation volume on the reproductive behavior was analyzed using logistic regression. The average value of humidity and day to day value of atmospheric pressure was taken while the total precipitation volume per day was noted for the analysis. All combinations of factors were tested without interactions. To avoid collinearity, correlation coefficients were calculated prior to performing logistic regression. The predictive variables were not highly correlated ($|r| < 0.7$); therefore, all variables were used for the Generalized Linear Model. All analysis were performed in the R program (R Core Team 2019).

4. RESULTS

4.1 General description of the Red Panda behaviors

Non-reproductive or non-social and reproductive or social behavior were identified as the two main categories of Red Panda behavior (Appendix 1, Figure 1). Based on scan sampling, a total of 16,416 events were recorded in which the male spent 96% ($n = 15,701$) and the female spent 95% ($n = 15,643$) of their total time budget for non-reproductive behaviors (Figure 1). Whereas the male and the female spent 1% ($n = 242$) and 2% ($n = 300$) times for reproductive behavior, respectively. Unfortunately, 3% ($n = 473$) of the data was deficient due to power outages (Figure 1).

The male and the female Red Pandas of the Central Zoo displayed similar non-reproductive behaviors (Figure 2). Out of the 15,701 events of the male's non-reproductive behavior, sleeping was accounted to 37% ($n = 5862$; Figure 2) of the total events, followed by locomotion (36%; $n = 5639$), resting (9%; $n = 1413$), feeding (9%; $n = 1380$), self-grooming (7%; $n = 1102$), and remaining 2% ($n = 305$) on the other behaviors like climbing, defecation, self-play, etc. Out of 15,643 events of female Red Panda, the highest number of events was recorded for sleeping, i.e., 51% of the total events of non-reproductive behavior ($n = 7909$), and followed by resting (15%; $n = 2361$), locomotion (11%; $n = 1775$), feeding (11%; $n = 1699$), self-grooming (10%; $n = 1623$) behaviors, and remaining 2% ($n = 276$) on the other behaviors (Figure 2).

In terms of reproductive behaviors, nine activities were classified under this category (Appendix 1, Figure 3). Among these behaviors, the male displayed 41% ($n = 99$) of the events for scent-marking, followed by chasing female (17%; $n = 41$), response to female (12%, $n = 30$), aggressiveness (12%; $n = 29$), sniffing (7%; $n = 16$), and feeding from the fecal tray (7%; $n = 16$). While 47% of the total number of activities of the female enumerated as the response to male ($n = 140$; Figure 3) followed by allogrooming (15%; $n = 46$), running from male (13%; $n = 39$), scent-marking (12%; $n = 36$), and aggressiveness (9%; $n = 28$).

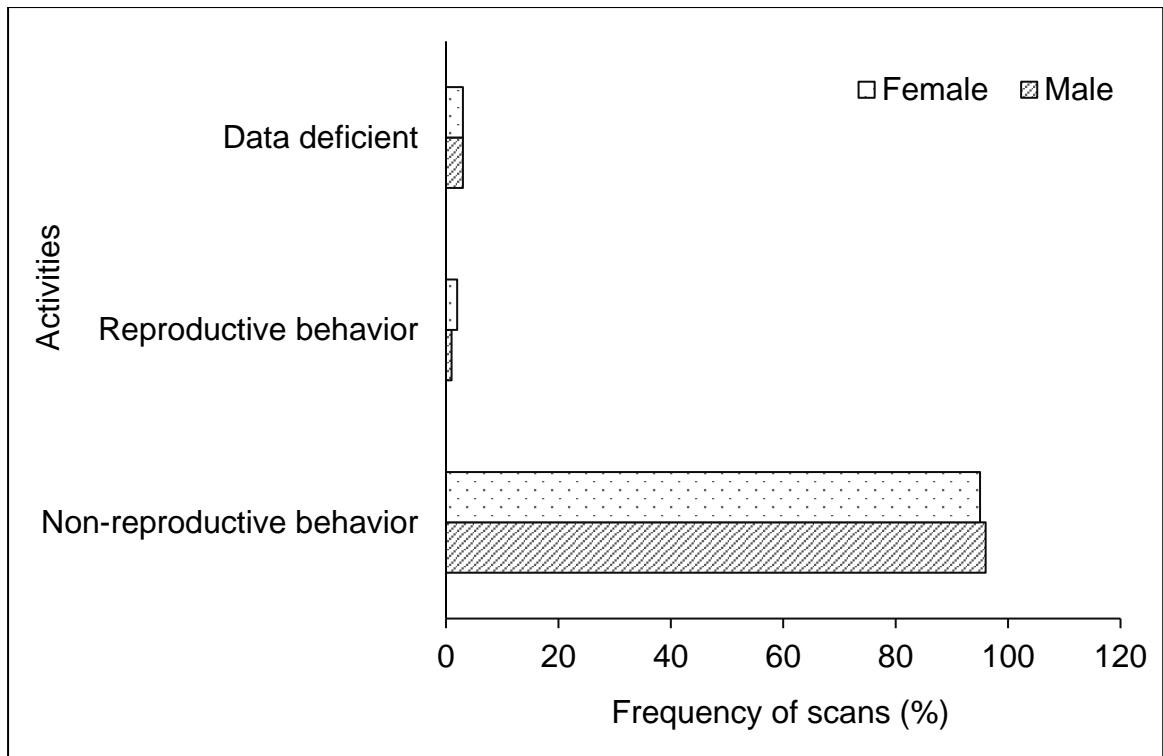


Figure 1 Non-reproductive and reproductive activities displayed by the male and the female Red Pandas during scan sampling in the Central Zoo, Kathmandu, Nepal, December 2020 – July 2021.

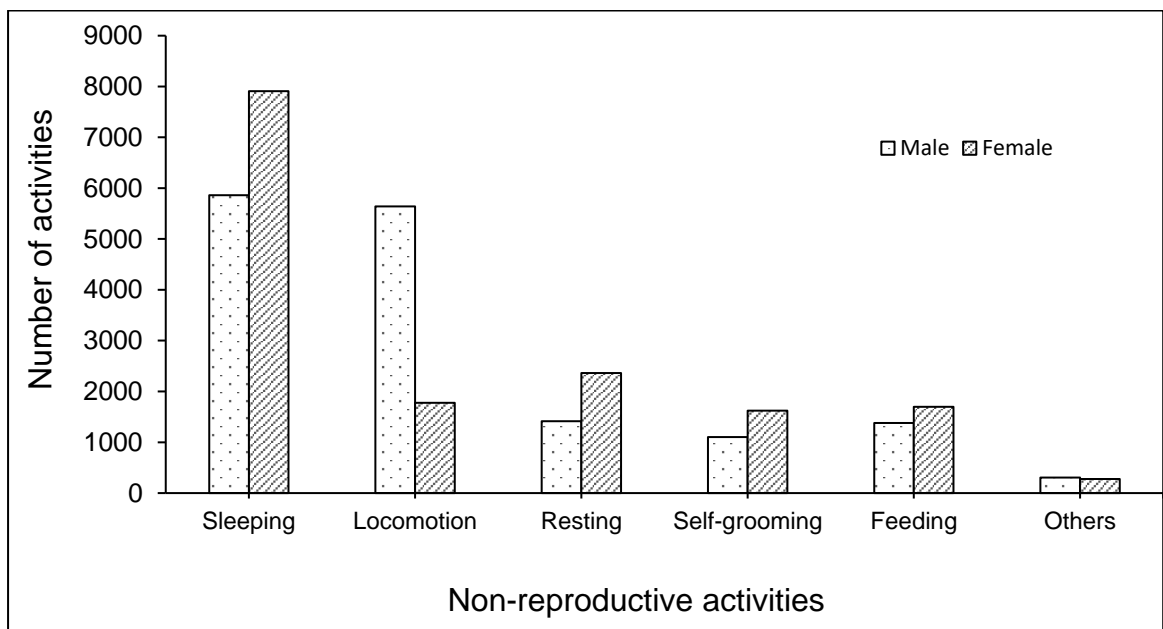


Figure 2 Non-reproductive activities displayed by the male and the female Red Pandas during scan sampling in the Central Zoo, Kathmandu, Nepal, December 2020 – July 2021.

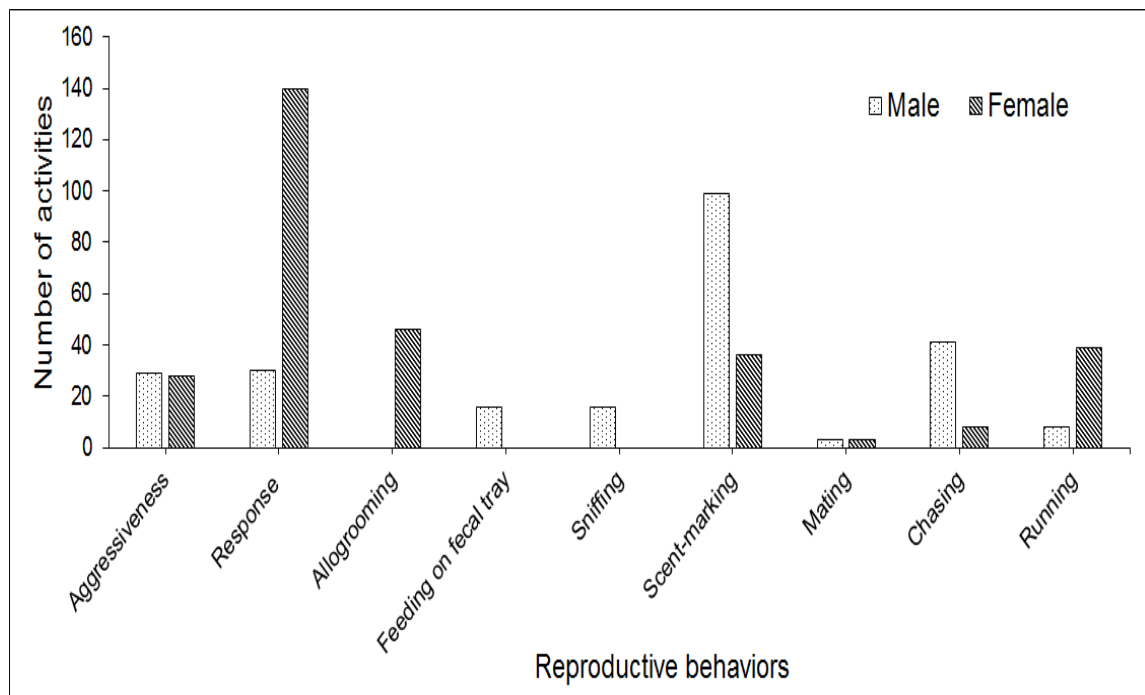


Figure 3 Reproductive activities displayed by the male and the female Red Pandas during scan sampling in the Central Zoo, Kathmandu, Nepal, December 2020 – July 2021.

4.1.1 Non-reproductive behaviors

The Red Pandas displayed thirteen similar non-reproductive behaviors namely locomotion, climbing, standing, feeding, resting, sleeping, self-grooming, drinking, defecation/urination, self-play, stretching, and response to humans. There was no difference on the observed behaviors displayed by the pair i.e scan and focal sampling showed the same behaviors. Based on the focal sampling, for these non-reproductive activities the male and the female spent 19,663.7 min and 19,613.4 min of the total activity budget, respectively.

The female used most of the time 9917.36 min (50.5% of the total non-reproductive observation time) for sleeping, and 2973.41 min (15.16% of the non-reproductive time) for resting on the log, tree branches and sometimes on the floor and nest box (Figure 4). Male showed comparatively less time 7693.6 min (39.12%) on sleeping, and 1551.59 min (7.8%) on resting (Figure 4). There was considerable variation in feeding and grooming behaviors between the female and the male ($p < 0.001$ for feeding; $p < 0.001$ for self-grooming; Table 1). She spent 2303.44 min (11.74% of total non-reproductive time budget) on feeding, and 2023.82 min (10.31% of total non-reproductive time budget) on self-grooming (Figure 4).

Similarly, the male spent 1726.17 min (8.7% of total non-reproductive time budget) on feeding, and 1297.59 min (6.5% of total non-reproductive time budget) on self-grooming behavior.

Locomotion was highly displayed behavior by the male, and he spent 36% (7079.02 min) of his total non-reproductive behavior time budget, while the female spent only 10.93% (2145.5 min) of her non-reproductive time budget on locomotion (Figure 4). Every day, the male locomoted about, all of the enclosed area and open land covering the average duration of observation 41.39 ± 12.42 min (Mean \pm SD, range 5.19 - 72.28 min; Table 1). The female locomoted shorter distance which averaged 12.54 ± 9.37 min (range 0.79 - 47.14; Table 1) and frequently followed a clear pattern from log to tree, occasionally circumnavigating the entire region. There was considerable variation regarding the locomotory behavior between the pair ($p < 0.001$; Table 1). Climbing was another form of locomotory action demonstrated by the Red Pandas as they climbed up and down the tree, logs, and walls. There was variation in climbing behavior between the pair ($p < 0.001$; Table 1). However, the male spent 0.9% (178.69 min) and the female spent 0.6% (125.14 min) of the total time budget on climbing the elevated areas (Figure 4).

The pair spent less time on the remaining activities. The male was observed to invest 53.61 min (0.27%) of the non-reproductive time budget on drinking water, 52.61 min on defecation (0.26%), 19.88 min on standing (0.1%), 5.23 min on response to humans (0.02%), 2.49 min on self-play (0.01%), 2.44 min on urination (0.01%), and 0.8 min on stretching behaviors (0.004%), respectively, (Figure 4). Regarding the activity levels of the female, she spent 75.5 min on defecation (0.3%), 26.43 min on standing (0.1%), 9.62 min on drinking (0.04%), 7.79 min on response to humans (0.03%), 2.31 min on stretching (0.01%), 1.74 min on self-play (0.008%), and 1.4 min on urination (0.007%). There wasn't any variation in the behavioral activities such as drinking, defecation, response to humans, and stretching between the male and female ($p > 0.05$; Table 1).

Table 1 Non-reproductive behaviors displayed by the male and the female Red Panda in the Central Zoo from December 2020 to July 2021. Range gives the minimum and maximum values for each activity in minutes. Bold values indicate significant ($p < 0.05$) in Mann-Whitney U Test.

Variables	Median (Range)		<i>P</i>
	Male	Female	
Locomotion	40.99 (5.19 – 72.28)	9.47 (0.79 – 47.14)	<0.001
Climbing	0.79 (0.08 – 4.51)	0.43 (0.05 – 4.73)	0.001
Standing	0.00 (0.7 – 1.18)	0.00 (0.08 – 1.26)	0.281
Sleeping	44.77 (14.72 – 78.23)	60 (10 – 95.71)	<0.001
Resting	6.98 (0.25 – 32.59)	16.61 (1.6 – 46.6)	<0.001
Self-grooming	6.47 (0.48 – 30.69)	11.28 (0.75 – 28.44)	<0.001
Feeding	8.95 (0.57 – 27.07)	12.8 (0.2 – 37.44)	<0.001
Drinking	0.23 (0.05 – 1.6)	0.00 (0.12 – 1.17)	<0.001
Defecation	0.27 (0.08 – 1.32)	0.37 (0.1 – 2.11)	0.002
Urination	0.00 (0.05 – 0.27)	0.00 (0.02 – 0.18)	0.251
Response (human)	0.00 (0.12 – 1.53)	0.00 (0.08 – 1.38)	0.398
Self-play	0.00 (0.38 – 0.86)	0.00 (0.07 – 1.67)	0.412
Stretching	0.00 (0.03 – 0.13)	0.00 (0.05 – 0.25)	0.031

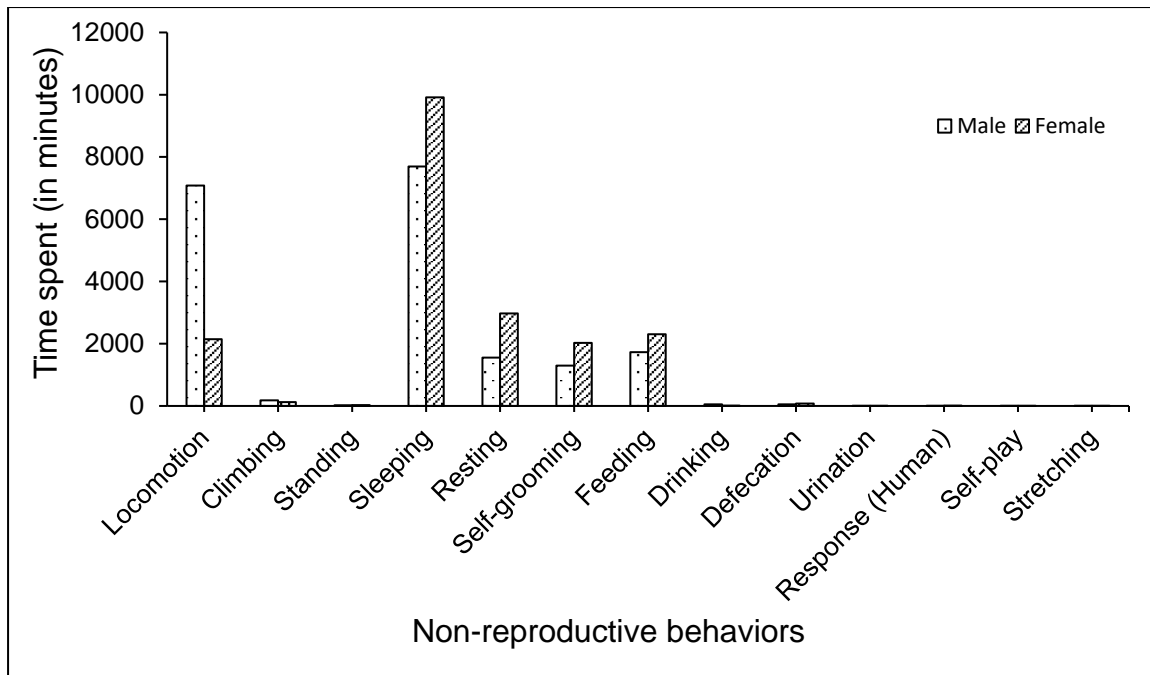


Figure 4 Non-reproductive activities displayed by the male and the female Red Panda based on focal sampling in the Central Zoo, Kathmandu, Nepal, December 2020 – July 2021.

4.1.2 Reproductive behaviors

During the research period based on focal sampling, nine reproductive behaviors were observed in Red Pandas (Table 2, Figure 4). The male spent 276.02 min and the female spent 326.68 min of the total time budget on the reproductive behaviors during the study period. The response was the first reproductive behavior observed after the pair were housed together during this study. The time spent by female was 192.7 min (58.98%) of her total reproductive behavior time budget on responding to the male while he spent 50.26 min (18.2%) on the response to the female (Figure 5). There was no variation in the aggressive behavior exhibited by the male and the female ($p > 0.05$; Table 2, Figure 5). Aggressive behavior led to chasing and running between the pair. Chasing ($p < 0.001$) and running against each other ($p < 0.001$) behaviors revealed a considerable difference among the sexes (Table 2). The male chased the female more often covering 32.7 min (11.84%) of his total time spent on reproductive activity (Table 5). The female chased him rarely. Hence, 4.43 min (1.3%) of her time budget was spent on chasing the male (Figure 5). On the contrary, 4.44 min (1.6%) of the male reproductive time budget and 29.02 min (8.8%) of the female reproductive time budget was invested on running away while one was chasing another (Figure 5).

Only the female displayed the signs of allogrooming which accounted to 50.93 min of her time budget (15.5%; Table 2, Figure 5). Anogenital scent marking was displayed highly by the male with a notable variation among the pair ($p < 0.001$; Table 2). The male scent-marked 81.88 min (29.6%; Figure 5) out of its total reproductive time while the female only spent 26.37 min (8.07%) of the time on this particular behavior (Figure 5). Similarly, the sniffing behavior also had significant difference ($p < 0.001$) with the male sniffing the scent marked areas more frequently and for longer duration measuring 39.09 min (14.16%; range: 0.037 – 2.8 min; Figure 4, Table 2). The female only performed 1.76 min of the time on sniffing (0.53%; Figure 5). An unusual behavior of the male namely feeding from the fecal tray was also observed which covered 46.59 min (16.87%; Figure 5) of its time budget. Three mating events were recorded during the entire study (Figure 4). The duration of mating was 7.35 min (Table 2). Copulation was male-initiated and took place on the ground in dorso-ventral position.

Table 2 Reproductive behaviors of the male and the female Red Panda in the Central Zoo from December 2020 to July 2021. Range gives the minimum and maximum values for each activity in minutes. Bold values indicate significant ($p < 0.05$) in Mann-Whitney U Test.

Variables	Median (Range)		<i>P</i>
	Male	Female	
Aggressiveness	0.00 (0.03 – 0.69)	0.00 (0.05 – 0.65)	0.958
Response (conspecific)	0.00 (0.03 – 8.04)	0.38 (0.08 – 10.58)	<0.001
Sniffing	0.00 (0.05 – 2.68)	0.00 (0.07 – 0.54)	<0.001
Scent-marking	0.24 (0.03 – 2.87)	0.00 (0.06 – 2.21)	<0.001
Chasing	0.08 (0.02 – 1.27)	0.00 (0.04 – 0.47)	<0.001
Running	0.00 (0.04 – 0.48)	0.8 (0.04 – 1.27)	<0.001

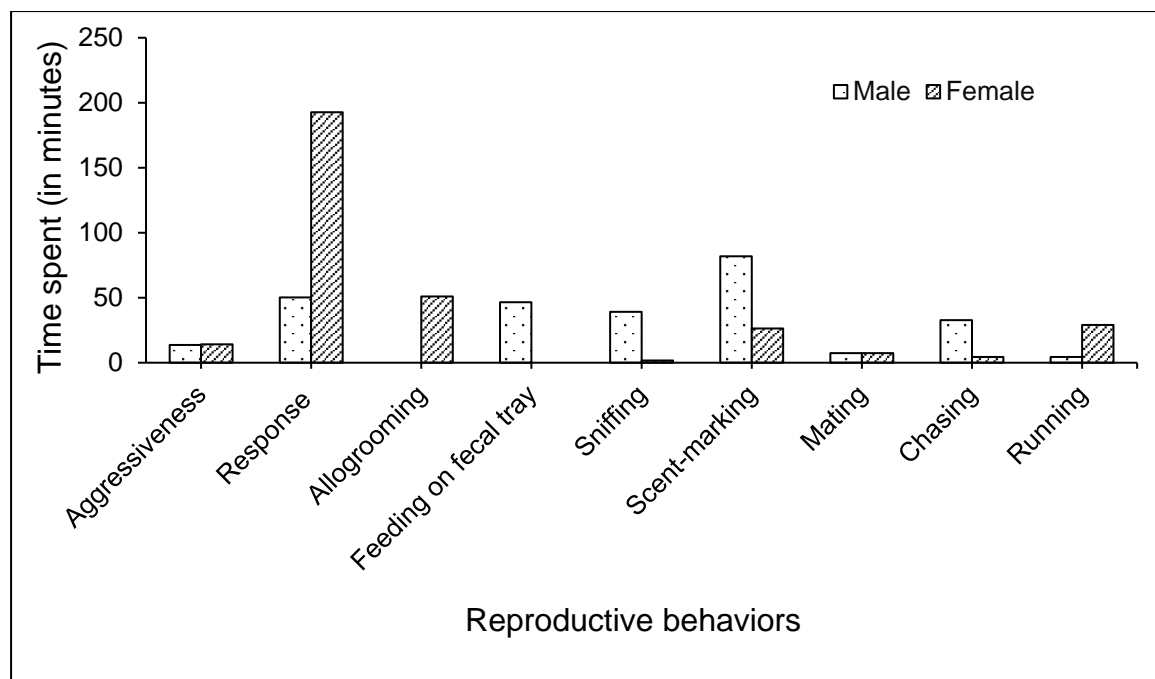


Figure 5 Reproductive activities displayed by the male and the female Red Panda based on focal sampling in the Central Zoo, Kathmandu, Nepal, December 2020 – July 2021.

4.2 Factors affecting reproductive behaviors in captivity

The reproductive behaviors were less likely to be displayed with the increased value of the daily rainfall volume and atmospheric pressure. Daily precipitation volume showed a significant negative role in the display of reproductive behaviors ($p = 0.0002$; Table 3). As the daily rainfall volume increased, it was less likely that the Red Pandas showed reproductive behaviors. In addition, the reproductive behaviors decreased with increasing atmospheric pressure and humidity as well (Table 3).

Table 3 Generalized Linear Model (GLM) for analysis of environmental variables humidity (%), atmospheric pressure (mBar), and precipitation volume (mm) that contributed to the events of reproductive activities of Red Pandas in the Central Zoo of Nepal during December 2020 to July 2021. Significant p values are in bold.

Variables	Estimate	SE	Lower limit	Upper limit	Z	P
Intercept	12.479	13.823	-12.705	21.133	0.903	0.3666
Humidity	-0.0001	0.003	-0.068	-0.02	-0.033	0.9737
Precipitation volume	-0.0458	0.0125	-0.037	0.015	-3.65	0.0002
Atmospheric pressure	-0.011	0.0135	-0.005	0.006	-0.815	0.4148

5. DISCUSSION

The present non-invasive method of behavioral monitoring revealed that the Red Panda exhibited reproductive behaviors at the Central Zoo regardless of its location at non-range elevation. Sexual intercourses between Red Pandas for multiple times at the Central Zoo suggest the zoo can establish a potential breeding center for this species. Higher rainfall is crucial influencing factor in suppressing reproductive behaviors. It was probably due to lack of sufficient enclosure space for the pandas in the Central Zoo for these activities during rainfall. During rainy days, the female generally lingered outdoors on tree branches while the male preferred staying indoors, resulting in less interaction between them. Both male and female pandas were seen to be passive and their overall activity decreased during the rainy days. It might be due to higher energy expenditure in rainy days. Energy expenditures are higher after rain than under heat or cold stress (Parker 1988) which might have affected the reproductive and overall behaviors. Not only in the Red Pandas, the decreased scent-marking activity was recorded in confined dwarf mongooses when the weather was cold, cloudy, or rainy (Rasa 1973).

The male was more active than the female in terms of percentage of time spent in different activities. The female was inactive most of the time and displayed sleeping and resting while the male spent majority of his time budget on moving around (locomotion and climbing). The difference in the behaviors might have occurred as the pair were trying to avoid each other most of the times at the start of the study. It has been observed that, following initial introduction, the animals often went into patterns of mutual tolerance through avoidance, with only rare instances of apparent threats or aggressive interactions (Roberts and Kessler 1979). To avoid any sexual contact, the female proceeded to stay away from the male as much as she could on the later observations too. She preferred to stay on logs and trees and the male favored the ground. Animals are also known to establish distinct resting and sleeping spots and kept clear distances between one another around the cage (Roberts and Kessler 1979). As logs and trees were accessible for sleeping and resting types of activity and ground for mobility, their selection of these sites may have caused the distinctions in their behavior. As the pair were confined together for the study in the male enclosure, the preference of the ground by the male may indicate an attempt to control the larger area and exhibit territoriality. Red Pandas are arboreal in nature and they prefer sleeping or resting up off the ground at higher areas (Kleiman 1983, Reid et al. 1991, Mainka and Zhang 1994, Jule 2008, Glatston 2021). Similarly, it is known that males patrol

their regions more than females (Spiezio et al. 2022). He also may possibly be waiting for the female on the ground for mating since it is a more secure location. The majority of carnivores, along with Red Pandas, have been observed to engage in copulation on the ground (Roberts and Gittleman 1984). Not only in this research, similar time budgets of male Red Pandas in locomotion were also recorded in earlier studies (Zhang et al. 2011, Spiezio et al. 2022).

In this study, the female spent more time on feeding than the male. It was probably due to dominant nature of female during breeding season. Females are known to control the reproductive behavior and social interactions in some animals like martens (Heath et al. 2001). When food was offered at the beginning of being housed together, she would chase the male away and feeding was done separately. Although food sharing and feeding in close proximity began within few days and there was never any instance of fighting over food, the male still displayed less feeding. While more food was available for the female increasing her feeding occurrences. However, contradict results were found on giant pandas where male giant panda spent more time on feeding than the female (Mainka and Zhang 1994, Liu et al. 2003).

Captive animals are often known to display stereotypic behaviors like repeated pacing and self-harm (Tepper et al. 1999, Swaisgood et al. 2001, Meagher et al. 2014). Stereotypic behaviors were not observed in this study. This might be because the animals were in favorable conditions with air-conditioned building, separate and large enclosure space with less disturbance and noise effects and availability of plenty food. Food was provided three times a day. Bamboo was readily available all the time naturally and also hung inside the enclosure. The provision of hiding space for the individuals i.e. man-made structure gave the opportunity to escape the outer disturbances positively impacting their general behaviors. According to the management requirements, visitors should only be permitted to observe one or two sides of the Red Panda cage such that animals especially solitary species won't get stressed (Glatston 1989). Conspecifics being present in the same space during the breeding season may be another factor, as their behaviors got directed more towards new social behavior than stereotypes. Studies have found that the captive animals display less stereotypes when housed in sufficient spaces with proper nutrition and enrichment (Molla et al. 2011, Antonenko et al. 2019). Housing the solitary animals in pairs have found to benefit other carnivores like leopard, tigers, etc. and lessened the

performance of abnormal behaviors (Duncan 1998, Swaisgood and Shepherdson 2005, Spiezio et al. 2022).

The female rested on tree branches and logs to avoid much contact with the male. The avoidance between the individuals during initial days of introduction has been known to study each other's behavior (Kachamankova and Zlatanova 2004). Response to female was observed as positive reproductive behavior in the male. Within a few weeks of introduction, the male would carefully observe the female's actions and make multiple attempts at copulation. The female would become agitated, resulting in either chasing or fighting. Fighting was unintentionally initiated by the male when attempting to establish physical contact. Fighting would also ultimately lead to chasing and running, and vice-versa. The female, in contrast, displayed response negatively in terms of her reproductive activity. As soon as the male was seen licking his genitalia or continually performing anogenital scent marking, she would run away and climb to higher spots before the male could make attempts, to prevent any type of contact. These behaviors conclude that the female was less sexually active than that the male. It was probably because the female experience short estrus period. Female pandas have a single estrus each spring with fertile period lasting for one to three days while the male is found to exhibit multiple seasonal cycles of behavioral changes (Kleiman 1983, Platz et al. 1983, Swaisgood et al. 2003). Throughout the female's estrus cycle, the majority of males exhibit consistent signals of interest in her, including numerous approaches, sniffing through the cage bars, and bleating (Swaisgood et al. 2003).

Scent marking was the most prominent reproductive behavior displayed by the pair. It was performed by rubbing the anogenital region against ground, logs and walls. However, urine marking wasn't observed in this study. It was probably due to cleaning of the ground every day by the caretakers in order to maintain hygiene. More scent marking events was displayed by the male than the female as in previous studies (Conover and Gittleman 1989). Generally, the individuals would typically mark in same locations where the other had marked as also noted in other carnivores (Heath et al. 2001, Antonenko et al. 2019). The male was more likely to observe sniffing scent-marked areas along with female's feces. The male as mentioned above was more sexually active than the female. Hence, he might have displayed higher scent-marking and sniffing behavior to communicate about the reproductive status and check the receptivity of the female, respectively. Mammalian carnivores frequently exhibit the activity of scent marking, which serves a variety of purposes like identity, reproductive status, spatial information and communication (Peters

and Mech 1975, Henry 1977, Mech 1977, Gosling 1982, Conover and Gittleman 1989, Gorman and Trowbridge 1989). Female marking may communicate rising receptivity to the courting male and may have contributed to increase in sexual excitement in males (Heath et al. 2001). The result was consistent with the finding that female rarely check scent-marks olfactorily (Roberts 1981).

The female showed a high level of grooming, along with exclusive display of allogrooming. She might have groomed herself to maintain her hygiene (fur and body) as she was housed in the enclosure (male enclosure) new to her. Furthermore, she was regularly observed grooming the male during the night. The male was only groomed while he was sleeping. If he was fully awake, such behavior was not permitted and the female didn't give it a try either. On the other hand, if the male woke up during this state, the female would be chased away or it led to fighting. Allogrooming might be one of the reliable signs of estrus behavior for the female and may have been performed by the female to establish social bonding with male and reduce his aggression. Allogrooming, which is typically only seen in solitary species during mating season or mother rearing babies, is a crucial habit in social animals as it aids in courtship, bonding, cleanliness, and rank establishing (Sachs 1988, Smolinsky et al. 2009, Ishii et al. 2017). Grooming is often used by females to strengthen social relationships (Henazi and Barrett 1999) and have known to reduce anxiety and stress of the grommee (Boccia et al. 1989).

Fecal trays were provided, and the animals were trained/habituated to defecate on them. Animals began defecating in unexpected areas after being confined together, including the floor, logs, and even the feeding tray. The male was observed to be feeding on the fecal matter in this study which was new to behavioral science in Red Panda. But it may be a form of extreme display of chemo-communication with presence of hormones in the feces that he might have shown along other reproductive behaviors like sniffing feces and licking scent-marked areas during breeding season. It also might be due to sexual frustration in male due to low pairing with a less receptive female. Deprivation of the opposite sex and chances to display sexual behavior in animals like tortoises, insects and even human has known to cause sexual tension which is relieved through variety of unusual behaviors like onanism, same-sex sexual behaviors or interspecific sexual practices (Bonnet et al. 2016, Sales et al. 2018). Nevertheless, three successful mating events were recorded during this entire study period. Prior to this event, the feeding activity of both animals reduced considerably and they were spotted resting together for a longer period during the day.

Copulation as mentioned in other studies took place on the ground in a dorsoventral position. The male mounted the female and clasped her by the abdomen during copulation with the occasional licking of the neck and shoulders (Roberts and Gittleman 1984).

This study didn't record any parturition behaviors, as no pregnancies/births arose from any of the observed mating. The female's acute lack of sexual interest may have resulted in a situation in which breeding was affected. The heavy infestation of fleas in the animals reported after copulation might also have caused adverse impact on the reproduction. Infestations of fleas and ticks may endanger the health of Red Pandas (Loeffler 2011). A study even revealed that such parasitic infection can be very stressful and has resulted in the killing of litters by their mothers (Sundell 2003). Another reason for the failed reproduction in spite of successful copulation in this case may be due to the presence of the Red Panda's enclosure space near that of Golden Jackal *Canis aureus* in the Central Zoo which is one of its potential predators. Red Panda cages should be kept at least 50 meters away from big predators and away from any potential predator species, according the management standards (Glatston 1989). The exhibits next to large carnivores had resulted in chronic stress associated with impaired immunological and reproductive function in them (Terio et al. 2004, Mason and Rushen 2008, Eriksson et al. 2010). Reproduction is a complicated set of processes, and a weak spot anywhere might cause the entire system to fail even though the other links are strong (Zhang et al. 2004). Hence, a detailed and in-depth study of factors like mate compatibility and choice, an individual's reproductive capacity, the quality of care offered, stress levels, diet, health state, etc. has to be studied to find accurate results.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The pair of the Red Panda housed in the Central Zoo of Nepal displayed less reproductive behaviors irrespective of the breeding season. The pair displayed similar non-reproductive behaviors namely, locomotion, climbing, standing, sleeping, resting, feeding, self-grooming, defecation, urination, drinking, response to the caretakers, self-play, and stretching. Female displayed higher levels of inactive behaviors like sleeping and resting while male spent most time on locomotion. Additionally, in comparison to the male, the female also exhibited higher signs of feeding and self-grooming behaviors.

Aggressiveness, chasing, running, response to the conspecific, scent-marking, sniffing, allogrooming, feeding from fecal tray and mating were the observed reproductive behaviors. The female spent most time responding to the activities of male. However, it was negative reproductive behavior. While for the male, responding to the female was positive reproductive behavior. The male was more sexually active and spent most of the time on anogenital scent marking. Allogrooming was displayed only by the female. While feeding from fecal tray was only observed from the male. The male tried to establish copulation many attempts while the female would run away or commence fighting because of his behavior. Copulation was only observed three times during the entire study period. The reproductive behavior was influenced by the precipitation. Precipitation had a significant negative relation to the display of reproductive behaviors.

6.2 Recommendations

The current study has limitations as only a pair of Red Panda was observed during the study period. The behaviors of animals are highly influenced by their hormonal changes. This study lacked to monitor the relation between the hormonal changes and different behaviors. However, this study provides detailed information on the behavior of the pandas in captivity during the breeding season. The next steps could be to increase the number of the individual pandas and future research should combine behavioral observations with endocrine hormone monitoring techniques to further understand the functions and mechanisms of these reproductive behavior strategies in the captive animals.

REFERENCES

- Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour* **49**(3-4): 227-266.
- Andres-Bray, T., Moller, P. and Powell, D. M. 2020. Preliminary model of personality structure in captive red pandas (*Ailurus fulgens*). *Journal of Zoo and Aquarium Research* **8**(1): 29-36.
- Antonenko, T., Ulitina, O., Pysarev, S. and Matsyura, A. 2019. Different enriched environments for Eurasian lynx in the Barnaul Zoo. *Ukrainian Journal of Ecology* **9**(4): 671-675.
- Balme, G. A., Lindsey, P. A., Swanepoel, L. H. and Hunter, L. T. 2014. Failure of research to address the rangewide conservation needs of large carnivores: leopards in South Africa as a case study. *Conservation Letters* **7**(1): 3-11.
- Bhatta, M., Shah, K. B., Devkota, B., Paudel, R. and Panthi, S. 2014. Distribution and habitat preference of red panda (*Ailurus fulgens fulgens*) in Jumla district, Nepal. *Open Journal of Ecology* **4**(15): 989.
- Bista, D., Baxter, G. S. and Murray, P. J. 2020. What is driving the increased demand for red panda pelts? *Human Dimensions of Wildlife* **25**(4): 324-338.
- Boccia, M. L., Reite, M. and Laudenslager, M. 1989. On the physiology of grooming in a pigtail macaque. *Physiology and Behavior* **45**(3): 667-670.
- Bonnet, X., Golubovic, A., Arsovski, D., Dordevic, S., Ballouard, J. M., Sterijovski, B. et al. 2016. A prison effect in a wild population: a scarcity of females induces homosexual behaviors in males. *Behavioral Ecology* **4**: 1206-1215.
- Chakraborty, R., Nahmo, L. T., Dutta, P. K., Srivastava, T., Mazumdar, K. and Dorji, D. 2015. Status, abundance, and habitat associations of the red panda (*Ailurus fulgens*) in Pangchen Valley, Arunachal Pradesh, India. *Mammalia* **79**(1): 25-32.
- Choudhury, A. 2001. An overview of the status and conservation of the red panda *Ailurus fulgens* in India, with reference to its global status. *Oryx* **35**(3): 250-259.
- Conde, D. A., Flesness, N., Colchero, F., Jones, O. R. and Scheuerlein, A. 2011. An emerging role of zoos to conserve biodiversity. *Science* **331**(6023): 1390-1391.
- Conover, G. K. and Gittleman, J. L. 1989. Scent-marking in captive red pandas (*Ailurus fulgens*). *Zoo Biology* **8**(2): 193-205.

- Conrad, M. 2021. Influence of Environmental Factors on Red Panda Welfare. M.Sc. Thesis. Department of Environmental Science and Policy, College of Science, George Mason University, Virginia, USA.
- Dechanupong, J. 2019. Maternal Behavior and Time Allocation of Red Panda (*Ailurus fulgens*) in Captivity. M.Sc. Thesis. Department of Environmental Science and Policy, College of Science, George Mason University, Virginia, USA.
- Delaski, K. M., Ramsay, E. and Gamble, K. C. 2015. Retrospective analysis of mortality in the North American captive red panda (*Ailurus fulgens*) population, 1992–2012. *Journal of Zoo and Wildlife Medicine* **46**(4): 779-788.
- Dorji, S., Rajaratnam, R. and Vernes, K. 2012. The Vulnerable red panda *Ailurus fulgens* in Bhutan: distribution, conservation status and management recommendations. *Oryx* **46**(4): 536-543.
- Dorji, S., Vernes, K. and Rajaratnam, R. 2011. Habitat correlates of the red panda in the temperate forests of Bhutan. *Plos One* **6**(10): 26483.
- Duncan, I. J. 1998. Behavior and behavioral needs. *Poultry Science* **77**(12): 1766-1772.
- Eriksson, P., Zidar, J., White, D., Westander, J. and Andersson, M. 2010. Current husbandry of red pandas (*Ailurus fulgens*) in zoos. *Zoo Biology* **29**(6): 732-740.
- Gebauer, A. 2022. The early days: maternal behaviour and infant development. *In The red Panda: Biology and Conservation of the First Panda*, Glatston A. R. (eds.). Academic Press, London, UK. p. 33-52.
- Gittleman, J. L. 1994. Are the pandas successful specialists or evolutionary failures? *BioScience* **44**(7): 456-464.
- Glatston, A. 1989. Management and husbandry guidelines for the red panda. *In The red or lesser panda studbook*, Glatston A. R. (eds.). Academic Press, London, UK. p. 33-52.
- Glatston, A., Wei, F., Than, Z. and Sherpa, A. 2015. *Ailurus fulgens*. The IUCN red list of threatened species <https://doi.org/10.2305/IUCN.UK>. Accessed on July 6, 2022.
- Glatston, A. R. 2021. Red panda: Biology and conservation of the First Panda 2nd ed. Academic Press. San Diego, 561 p.
- Gorman, M. L. and Trowbridge, B. J. 1989. The role of odor in the social lives of carnivores. *In Carnivore behavior, ecology, and evolution*, Gittleman J. L. (eds.). Chapman and Hall, London, UK. p. 55-78
- Gosling, L. 1982. A reassessment of the function of scent marking in territories. *Zeitschrift fur Tierpsychologie* **60**(2): 89-118.

- Groves, C. 2011. The taxonomy and phylogeny of *Ailurus*. *In* Red Panda: Biology and Conservation of the First Panda, Glatston, A. R. (eds.). Academic Press, London, UK, p. 101-124.
- Heath, J. P., McKay, D. W., Pitcher, M. O. and Storey, A. E. 2001. Changes in the reproductive behaviour of the endangered Newfoundland marten (*Martes americana atrata*): implications for captive breeding programs. *Canadian Journal of Zoology* **79**(1): 149-153.
- Henazi, S. P. and Barrett, L. 1999. The value of grooming to female primates. *Primates* **40**(1): 47-59.
- Henry, J. D. 1977. The Use of Urine Marking in the Scavenging Behavior of the Red Fox (*Vulpes vulpes*). *Behaviour* **61**(1-2): 82-105.
- Hill, S. P. and Broom, D. M. 2009. Measuring zoo animal welfare: theory and practice. *Zoo Biology* **28**(6): 531-544.
- Hu, Y., Thapa, A. and Wei, F. 2020. *Ailurus fulgens* (Himalayan Red Panda) and *Ailurus styani* (Chinese Red Panda). *Trends in Genetics* **36**(8): 624-625.
- Ishii, N., Kato, T., Uno, T., Tanaka, I., Kajigaya, H. and Hayama, S. I. 2017. The Number of Louse Eggs on Wild Japanese Macaques (*Macaca fuscata*) Varies with Age, but Not with Sex or Season. *International Journal of Primatology* **38**(6): 1090-1101.
- Johnson, K. G., Schaller, G. B. and Jinchu, H. 1988. Comparative behavior of red and giant pandas in the Wolong Reserve, China. *Journal of Mammalogy* **69**(3): 552-564.
- Jones, M. L. 2022. A brief history of the red panda in captivity. *In* Red panda: biology and conservation of the First Panda. Glatston, A. R. (eds.). Academic Press, London, UK, p. 213–229.
- Jule, K. 2008. Effects of Captivity and Implications for Ex-situ Conservation: with special reference to red panda (*Ailurus fulgens*). Ph.D. Dissertation. Department of Psychology, University of Exeter, Exeter, UK.
- Kachamakova, M. and Zlatanova, D. 2014. Behaviour of Eurasian lynx, *Lynx lynx* (L.), in captivity during the breeding season. *Acta Zoologica Bulgarica* **66**: 365-371.
- Kappelhof, J. and Weerman, J. 2020. The development of the Red panda *Ailurus fulgens* EEP: from a failing captive population to a stable population that provides effective support to in situ conservation. *International Zoo Yearbook* **54**(1): 102-112.
- Kathleen, M. and Tomborg, C. 2007. Sources of stress in captivity. *Applied Animal Behavior Science* **102**: 262-302.

- Kiik, K., Maran, T., Nagl, A., Ashford, K. and Tammaru, T. 2013. The causes of the low breeding success of European mink (*Mustela lutreola*) in captivity. *Zoo Biology* **32**(4): 387-393.
- Kleiman, D. G. 1983. Ethology and reproduction of captive giant pandas (*Ailuropoda melanoleuca*). *Zeitschrift fur Tierpsychologie* **62**(1): 1-46.
- Leus, K. 2011. The Global Captive Population of the Red Panda—Possibilities for the Future. *In Red panda: biology and conservation of the First Panda*. Glatston, A. R. (eds.). Academic Press, London, UK, p. 335-356.
- Liu, D., Wang, Z., Tian, H., Yu, C., Zhang, G., Wei, R., et al. 2003. Behavior of giant pandas (*Ailuropoda melanoleuca*) in captive conditions: Gender differences and enclosure effects. *Zoo Biology* **22**(1): 77-82.
- Loeffler, K. 2011. Red panda husbandry for reproductive management. *In Red panda: biology and conservation of the First Panda*. Glatston, A. R. (eds.). Academic Press, London, UK, p. 231-255.
- Mainka, S. A. and Zhang, H. 1994. Daily activity of captive giant pandas (*Ailuropoda melanoleuca*) at the Wolong Reserve. *Zoo Biology* **13**(1): 13-20.
- Marneweck, C., Butler, A., Gigliotti, L., Harris, S., Jensen, A., Muthersbaugh, M., et al. 2021. Shining the spotlight on small mammalian carnivores: global status and threats. *Biological Conservation* **255**: 109005.
- Martin-Wintle, M. S., Shepherdson, D., Zhang, G., Huang, Y., Luo, B. and Swaisgood, R. R. 2017. Do opposites attract? Effects of personality matching in breeding pairs of captive giant pandas on reproductive success. *Biological Conservation* **207**: 27-37.
- Mason, G. and Rushen, J. 2008. Stereotypic animal behaviour: fundamentals and applications to welfare 2nd ed. Cromwell press, Trowbridge, 379 p.
- Meagher, R. K., Ahloy Dallaire, J., Campbell, D. L., Ross, M., Moller, S. H., Hansen, S. W., et al. 2014. Benefits of a ball and chain: Simple environmental enrichments improve welfare and reproductive success in farmed American mink (*Neovison vison*). *Plos One* **9**(11): 110589.
- Mech, L. D. 1977. Wolf-pack buffer zones as prey reservoirs. *Science* **198**(4314): 320-321.
- Molla, M. I., Quevedo, M. A. and Castro, F. 2011. Bobcat (*Lynx rufus*) breeding in captivity: The importance of environmental enrichment. *Journal of Applied Animal Welfare Science* **14**(2): 85-95.
- Parker, K. L. 1988. Effects of heat, cold, and rain on coastal black-tailed deer. *Canadian Journal of Zoology* **66**(11): 2475-2483.

- Pedrono, M., Tuan, H. M., Chouteau, P. and Vallejo, F. 2009. Status and distribution of the Endangered banteng *Bos javanicus birmanicus* in Vietnam: a conservation tragedy. *Oryx* **43**(4): 618-625.
- Peters, R. P. and Mech, L. D. 1975. Scent-marking in wolves: radio-tracking of wolf packs has provided definite evidence that olfactory sign is used for territory maintenance and may serve for other forms of communication within the pack as well. *American Scientist* **63**(6): 628-637.
- Platz, C., Wildt, D., Howard, J. and Bush, M. 1983. Electroejaculation and semen analysis and freezing in the giant panda (*Ailuropoda melanoleuca*). *Reproduction* **67**(1): 9-12.
- Pradhan, S., Saha, G. K. and Khan, J. A. 2001. Ecology of the red panda *Ailurus fulgens* in the Singhalila National Park, Darjeeling, India. *Biological Conservation* **98**(1): 11-18.
- Princee, F. P. and Glatston, A. R. 2016. Influence of climate on the survivorship of neonatal red pandas in captivity. *Zoo Biology* **35**(2): 104-110.
- R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.
- Ramirez, O., Altet, L., Ensenat, C., Vila, C., Sanchez, A. and Ruiz, A. 2006. Genetic assessment of the Iberian wolf *Canis lupus signatus* captive breeding program. *Conservation Genetics* **7**(6): 861-878.
- Rasa, O. A. E. 1973. Marking behaviour and its social significance in the African dwarf mongoose, *Helogale undulata rufula*. *Zeitschrift fur Tierpsychologie* **32**(3): 293-318.
- Reid, D., Jinchu, H. and Yan, H. 1991. Ecology of the red panda *Ailurus fulgens* in the Wolong Reserve, China. *Journal of Zoology* **225**(3): 347-364.
- Roberts, M. S. 1981. The reproductive biology of the red panda, *Ailurus fulgens*, in captivity. M.Sc. Thesis. University of Maryland, College Park, USA.
- Roberts, M. S. and Gittleman, J. L. 1984. *Ailurus fulgens*. *Mammalian Species*, **222**: 1-8.
- Roberts, M. S. and Kessler, D. S. 1979. Reproduction in red pandas, *Ailurus fulgens* (Carnivora: Ailuropodidae). *Journal of Zoology* **188**(2): 235-249.
- Sachs, B. D. 1988. The development of grooming and its expression in adult animals. *The Annals of the New York Academy of Sciences* **525**(1): 1-17.
- Sales, K., Trent, T., Gardner, J., Lumley, A. J., Vasudeva, R., Michalczyk, L. and Gage, M. J. 2018. Experimental evolution with an insect model reveals that male

- homosexual behaviour occurs due to inaccurate mate choice. *Animal Behaviour* **139**: 51-59.
- Sharma, H. P. and Achhami, B. 2022. Gastro-intestinal parasites of sympatric red panda and livestock in protected areas of Nepal. *Veterinary Medicine and Science* **8**(2): 568-577.
- Sharma, H. P. and Belant, J. L. 2009. Distribution and observations of red pandas *Ailurus fulgens fulgens* in Dhorpatan Hunting Reserve, Nepal. *Small Carnivore Conservation* **40**: 33-35.
- Sharma, H. P., Belant, J. L. and Swenson, J. E. 2014a. Effects of livestock on occurrence of the Vulnerable red panda *Ailurus fulgens* in Rara National Park, Nepal. *Oryx* **48**(2): 228-231.
- Sharma, H. P., Swenson, J. and Belant, J. L. 2014b. Seasonal food habits of the red panda (*Ailurus fulgens*) in Rara National Park, Nepal. *The Italian Journal of Mammalogy* **25**(1): 47-50.
- Slof Pacilio, M. 2020. Why are you not breeding? M.Sc. Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.
- Smolinsky, A. N., Bergner, C. L., LaPorte, J. L. and Kalueff, A. V. 2009. Analysis of grooming behavior and its utility in studying animal stress, anxiety, and depression. *In* Mood and anxiety related phenotypes in mice: Characterization using behavioural tests. Gould, T. D. (eds.). Humana Press, New York, p. 21–36.
- Spiezio, C., Altamura, M., Weerman, J. and Regaiolli, B. 2022. Behaviour of Zoo-Housed Red Pandas (*Ailurus fulgens*): A Case-Study Testing the Behavioural Variety Index. *Journal of Zoological and Botanical Gardens* **3**(2): 223-237.
- Sundell, J. 2003. Reproduction of the least weasel in captivity: basic observations and the influence of food availability. *Acta Theriologica* **48**(1): 59-72.
- Swaigood, R. R. and Shepherdson, D. J. 2005. Scientific approaches to enrichment and stereotypies in zoo animals: what's been done and where should we go next? *Zoo Biology* **24**(6): 499-518.
- Swaigood, R. R., White, A. M., Zhou, X., Zhang, H., Zhang, G., Wei, R., et al. 2001. A quantitative assessment of the efficacy of an environmental enrichment programme for giant pandas. *Animal Behaviour* **61**(2): 447-457.
- Swaigood, R. R., Zhou, X., Zhang, G., Lindburg, D. G. and Zhang, H. 2003. Application of behavioral knowledge to conservation in the giant panda. *International Journal of Comparative Psychology* **16**(2): 65-84.

- Tepper, E., Hare, V., Swaisgood, R., Lindburg, D., Quan, Z., Ripsky, D., et al. 1999. Evaluating enrichment strategies with giant pandas at the San Diego Zoo. *In*: Hare V. J., Worley K. E., Myers K. (eds.). Proceedings of the Fourth International Conference on 'Environmental Enrichment. Shape of Enrichment', San Diego, USA, Shape of Enrichment: 226-239.
- Terio, K. A., Marker, L. and Munson, L. 2004. Evidence for chronic stress in captive but not free-ranging cheetahs (*Acinonyx jubatus*) based on adrenal morphology and function. *Journal of Wildlife Diseases* **40**(2): 259-266.
- Thapa, A., Hu, Y. and Wei, F. 2018. The endangered red panda (*Ailurus fulgens*): Ecology and conservation approaches across the entire range. *Biological Conservation* **220**: 112-121.
- Vanhoomissen, C. 2016. Activity budget of two giant pandas at Pairi Daiza Zoo (Belgium) and the possible influence of environmental factors. M. Sc. Thesis. Faculty of Veterinary Medicine, Ghent University, Ghent, Belgium.
- Wei, F., Feng, Z., Wang, Z. and Hu, J. 1999. Current distribution, status and conservation of wild red pandas *Ailurus fulgens* in China. *Biological Conservation* **89**(3): 285-291.
- Willcox, D. 2020. Conservation status, ex situ priorities and emerging threats to small carnivores. *International Zoo Yearbook* **54**(1): 19-34.
- Yonzon, P. B. 1989. Ecology and conservation of the red panda in the Nepal Himalayas. Ph.D. Dissertation, University of Maine, Orono, USA.
- Yonzon, P. B. and Hunter Jr, M. L. 1991. Conservation of the red panda *Ailurus fulgens*. *Biological Conservation* **57**(1): 1-11.
- Zhang, G., Swaisgood, R. R. and Zhang, H. 2004. Evaluation of behavioral factors influencing reproductive success and failure in captive giant pandas. *Zoo Biology* **23**(1): 15-31.
- Zhang, Z., Hu, J., Han, Z. and Wei, F. 2011. Activity patterns of wild red pandas in Fengtongzhai Nature Reserve, China. *Italian Journal of Zoology* **78**(3): 398-404.

APPENDICES

Appendix 1: Ethogram with the description of non-reproductive and reproductive behaviors by the Red Pandas in the Central Zoo, Nepal

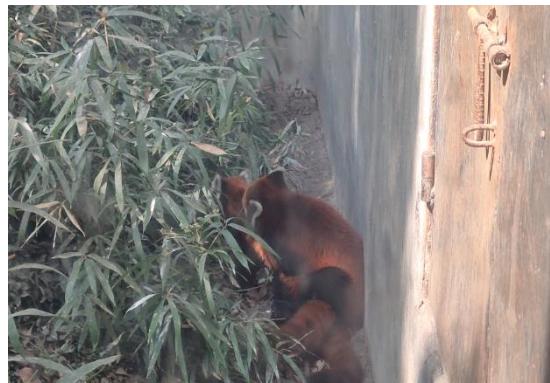
S.N.	Behavior	Description	Type
1	Locomotion	Using all four limbs running or bounding on ground, logs, and tree branches	Non-reproductive behavior
2	Climbing	Climbing up or down a tree trunk, branch, stairs, wall, or elevated surface (horizontal or vertical)	
3	Standing	Standing on all fours or on back two paws motionless	
4	Sleeping	Lying-sleeping (either curled in a ball or lying flat out); unresponsive to noise/activity	
5	Resting	Lying or sitting, head up, eyes open, reaction to surroundings in some manner (head, eye, ear or tail movement)	
6	Self-grooming	Scratching or licking the fur or skin in a consistent repetitive action on self	
7	Feeding	Eating provisioned food or browsing in enclosure or open natural space	
8	Drinking	Drinking provided water	
9	Defecation/ Urination	Discharge of feces/urine from body	
10	Response to human	Paying attention to the caretakers and visitors	
11	Stretching	Stretching one body or yawning	
12	Out of sight	Not visible to the observer or Malfunctioning of the devices (power-cuts)	

13	Self-play	Purposeless activity with self (i.e. rolling, tail-chasing) but not repetitive or playing with the food trays	
14	Aggressiveness	Make aggressive physical contact with another conspecific, typically including arching of the tail and back, hitting, or biting	Reproductive behavior
15	Allogrooming	Licking another panda	
16	Response to next panda	Paying attention to the conspecific	
17	Feeding from fecal tray	Feeding on feces and remaining undigested food from the fecal tray	
18	Sniffing	Sniffing the urinated areas or feces	
19	Anogenital scent marking	Lifting tail and rubbing anus or genital area along the ground or an object; either in a sideways or front to back motion	
20	Mating	Male mounts the female and intromission take place	
21	Chasing	Chasing the opposite sex	
22	Running	Running from the opposite sex	

PHOTO GALLERY



Mating inside enclosure



Mating (in natural space)



Drinking water



Feeding (provided food)



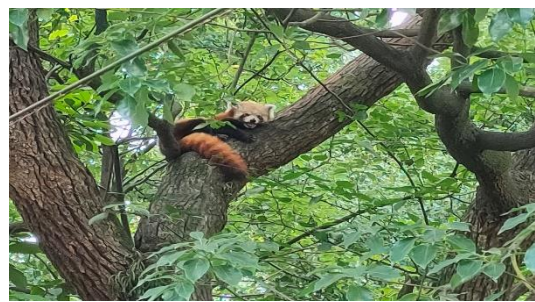
Resting on wooden plank



Feeding (provided bamboo)



Allogrooming



Resting on tree