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Time Budget and Activity Patterns During the Mating Period of Rescued Leopard Cat (*Prionailurus bengalensis*) in Captivity

Feng Gao[1]*, Ying Tian[1], Jia Tang[1], LiJun Liu[1], Xinyuan Du[1], Dajun Deng[2], Wei Li[2], Yang Liu[3], Guoxiang Yang[4] and Jing Chen[4]

[1]*Beijing Wildlife Rescue and Rehabilition Center, Beijing, 101300, China*
[2]*Henan Wildlife Conservation Center, Henan, 450044, China*
[3]*Tianjin Wildlife Rescue and Training and Breeding Center, 301600, Tianjin, China*

ABSTRACT

This study investigated the activity patterns and time budgets of *Prionailurus bengalensis* during the breeding season. One male and one female leopard cat in captivity were observed from February 2 to July 3, 2023, using video surveillance at the Beijing Wildlife Rescue Center in Beijing, China. Behavioral data were collected for each individual using ad libitum sampling over a continuous 24-hour period, divided into daytime (06:00–18:00) and nighttime (18:00–06:00) intervals. The observed behaviors and corresponding time budgets were recorded and used to construct an ethogram. Subsequently, the daily activities of the male and female were analyzed and compared. The recorded behaviors were categorized into the following types: grooming, feeding, resting, thermoregulation, vigilance, parental care, conflict, locomotion, elimination, sniffing, and copulation. The cats exhibited nocturnal activity patterns, being more active at night and resting primarily during the day. Female cats rested more during the daytime than males, while males were more active at night. Specifically, male activity peaked between 22:00–23:00 and 00:00–02:00, whereas female activity peaked between 22:00–23:00 and 06:00–07:00. Additionally, females demonstrated longer nursing durations during the day and engaged in more nighttime feeding compared to males. Male cats did not participate in the feeding or care of the young during the breeding season. Overall, the daily activity patterns of male and female leopard cats showed distinct differences during the mating period.

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GF conceived the project. GF and TY was responsible for the field animal survey and data analysis, and wrote the first draft. TJ, DD, LW, LY, YG, LL, DX and CJ provided suggestions for the data analysis of the thesis. All the authors have reviewed and approved the final version.

Key words
Behavior, Ethogram, Felidae, *Prionailurus bengalensis*

INTRODUCTION

Ex-situ conservation is a method used to safeguard vulnerable wildlife species from significant declines in their natural populations by maintaining and studying them outside of their native habitats (Kasso and Balakrishnan, 2013). Within wildlife rescue centers, behavioral studies serve as evidence-based tools that are essential for effective population management. Comparative analyses between captive and wild populations provide critical insights into the species minimum ecological requirements and can inform strategies for successful reintroduction.

Variations in mammalian activity patterns are influenced by a variety of environmental factors, including photoperiod (Kavanau and Ramos, 1975), temperature, predator-prey dynamics (Cloudsley-Thompson, 1961), and competition avoidance (Hayward and Hayward, 2007). Additionally, these patterns can be shaped by behavioral processes related to reproduction (Schmidt, 1999; Zalewski, 2001). While felids are generally considered crepuscular or nocturnal, many are capable of functioning under a broad spectrum of light conditions. However, detailed knowledge of the activity patterns and the factors influencing them remains limited for many felid species (Schmidt *et al*., 2009).

The daily activity pattern of the leopard cat *(Prionailurus bengalensis*) is rhythmic. Although felids typically display crepuscular and nocturnal behavior, they are capable of adapting to various lighting conditions. The circadian rhythms of both leopard cats and their prey are relatively conservative, but they exhibit some seasonal flexibility, potentially influenced by prey distribution and environmental changes. Activity peaks are typically observed during twilight and nighttime h (Schmidt *et al*., 2009). Studies suggest that leopard cats adjust their activity patterns based on human disturbance: they are more nocturnal in human-dominated landscapes, whereas in protected areas such as national parks and wildlife

* Corresponding author: adio6182000@163.com
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reserves, their activity may be more evenly distributed across the day.

The breeding period represents a critical phase in the life cycle of animals, during which behavioral patterns often differ markedly from other life stages. Reproductive behavior plays a fundamental role in species propagation and gene transmission, and has been a major focus of wildlife behavioral research. While many previous studies have examined the daily activity rhythms of wild ocelots, their predominantly nocturnal behavior makes direct field observations of reproductive activities such as estrus, mating, birthing, and maternal care extremely difficult (Liu *et al*., 2023). As such, there has been limited research on time allocation and daily activity rhythms during the ocelot's breeding period.

Therefore, observing the breeding-period behaviors of captive leopard cats offers a valuable opportunity to obtain reliable behavioral data. Such information is crucial for improving artificial breeding efforts and developing effective conservation strategies for the species in both captive and wild settings.

MATERIALS AND METHODS

Captivity and management

This study was conducted at the Wildlife Rescue Center in Beijing, China. The research area is located separately from the public exhibition zone, ensuring that the animals are not disturbed by visitors. The leopard cats were housed in a facility covering a total area of 240 m², which is divided into a row of ten individual enclosures (Fig. 1A).

Fig. 1. The enclosure for Leopard Cat *Prionailurus bengalensis* at the Beijing Wildlife Rescue Center, Beijing, China. A, animal housing; B, environment inside the enclosure.

From February 2 to July 3, 2023, the behaviors of a male and a female leopard cat in captivity were systematically observed. Our research team monitored the reproductive behaviors of captive individuals throughout the year and found that mating activities primarily occurred during the spring. The observation period described in this study captures a complete record of breeding behaviors in *Prionailurus bengalensis*.

Mating introductions were arranged when signs of courtship behavior were observed, such as increased attention to the opposite sex or attempts to initiate physical contact. Three enclosures were used for mating introductions involving one adult male and one adult female in estrus. However, only two pairs (one male and one female in each pair) met the criteria for behavioral observation. All individuals used in this study were rescued from the wild in 2019 and 2020.

The observation enclosure was divided into two sections. The cats typically remained in the primary section, while the secondary section was used solely by the zookeeper. The first sections of each enclosure were separated by concrete walls and wire mesh, while the second sections were interconnected and could be opened to allow free movement between enclosures.

In compliance with animal welfare standards, feeding occurred daily between 16:00 and 17:00. Continuous monitoring was carried out to detect any abnormal behaviors in captivity. The diet included whole prey such as mice, chicks, and rabbits. The enclosures were open-air and incorporated both natural and artificial environmental elements. The ground was covered with soil and leaf litter, and scattered vegetation and dry logs created a semi-natural setting. A wooden box and an artificial log were placed in one corner to serve as shelter. Fresh, clean water was available ad libitum via a pool, which occupied approximately one-eighth of the total enclosure area.

Data collection

Because animal behavior is influenced by their environment, we employed Fluorite C8PF video monitoring equipment to ensure comprehensive coverage of the enclosures. Camera angles and positions were carefully adjusted to maximize the field of view, capturing as much of the enclosure area as possible. Surveillance footage was regularly transferred to a computer connected to the camera system for analysis.

Observations were conducted by a single researcher using the focal animal sampling method. Behavioral data were recorded during both daytime (06:00–18:00) and nighttime (18:00–06:00) periods. The behavior of the captive leopard cats was monitored over 152 days, yielding a total of 4,320 h of video and 41,148 recorded behavioral events during the breeding season.

Thirteen distinct behaviors were identified and included in a behavioral spectrum map. The definitions of each behavior were adapted from the Standardized Ethogram for the Felidae (Liu *et al*., 2023; Stanton *et*

al., 2015) to suit the specific characteristics of the study animals. Behaviors were classified as either inactive (resting) or active (all other behaviors).

i) *Feeding behavior*: In order to meet their energy needs, the leopard cat preys on mice, birds or plants, water and mineral intake, and Suckling behavior.
ii) *Thermo-regulatory behavior*: The adaptive behavior of the ocelot in response to changes in the external environment in order to maintain constant body temperature.
iii) *Parental behavior*: The nurturing behavior of an adult female ocelot toward her young.
iv) *Conflict behavior*: A series of aggressive, competitive, or submissive behaviors that occur between individuals of leopard cat.
v) *Communication behavior*: The act of transmitting information between different individuals inside and outside the ocelot population.
vi) *Resting behavior:* Under natural living conditions, the leopard cat maintains its body state in a certain period of time without changing its behavior, and its body often presents a relaxed state.
vii) *Locomotive behavior*: The ocelot moves its body forward by interleaving its limbs.
viii) *Other behavior*: Some unusual behaviors of leopard cat in search of survival or comfort.
ix) *Elimination behavior*: The defecation of an ocelot after the digestion of food,Urination and occasional emergency defecation and urination.
x) *Groom behavior*: Cat cleans itself by licking, scratching, biting or chewing the fur on its body. May also include the licking of a front paw and wiping it over one's head.
xi) *Vigilance behavior*: Leopard cat observe changes in their surroundings or specific targets in order to gain useful information and make adaptive responses.
xii) *Sniffing behavior*: A sensory behavior in which leopard cat actively sample odors through their nasal passages to obtain odor information.
xiii) *Copulation behavior*: Copulation male mounts female and intromission is achieved.

Daily activity patterns were established by calculating the proportion of active behavior events per time interval. A time budget was computed for each behavioral category by expressing the percentage of time spent per day, and mean activity durations were calculated based on the 152 days of observation. Since the daily time budget data were not normally distributed, we used the Mann–Whitney U test to compare male and female activity budgets. All statistical analyses were conducted using SPSS software version 25.0, with a significance level set at $p < 0.05$.

RESULTS

A total of 4,320 h of focal observations were analyzed for both the male and female leopard cats during their mating period. At certain times during the data collection, the animals were not visible within the monitored field of view, as they remained inside or outside of shelter areas. These periods of invisibility were excluded from all behavioral analyses. Significant differences were observed in time allocation across the 13 identified behaviors (One-way ANOVA, F = 1.36, df = 5, P = 0.357; Fig. 2). Throughout the day, the leopard cats spent the most time on locomotive behavior (Mean ± SE: 32.35%±10.229%, n= 10) and inspection behavior (18.89%±6.001%, n= 10), followed by grooming (22.53%±7.126%, n= 10) and resting (20.42%±6.456%, n= 10). Less time was spent on sniffing (4.48%±1.418%, n= 10), feeding (0.64%±0.201%, n= 10), defecation (0.37%±0.118%, n= 10), parental care (0.07%±0.021%, n= 10), communication (0.02%±0.008%, n= 10), conflict (0.14%±0.044%, n= 10), thermoregulation (0.14%, n= 10), other behaviors (0.17%, n= 10), and aggregation (0.02%, n= 10) the latter being the least frequently observed behavior.

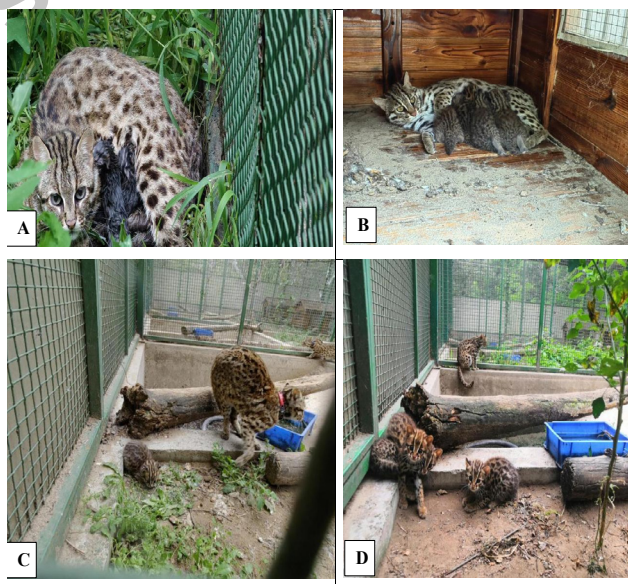

Fig. 2. Some functional displays of leopard cat *Prionailurus bengalensis* in captivity. A, leopard cat giving birth; B, leopard cat lactation; C, male cat (Blue collar), female cat (Red collar); D, leopard cat cub.

Over the 152-days observation period, the male leopard cat was out of view for an average of 30 min per day, while the female was not visible for approximately 10 min per day. In total, 41,148 valid behavioral events were

recorded during the breeding season. Some behavioral examples are illustrated in Figure 2.

Daily activity pattern of leopard cat

The daily activity patterns of both male and female leopard cats exhibited a similar bimodal distribution. However, the peak activity in females occurred slightly later than that observed in males (Fig. 3).

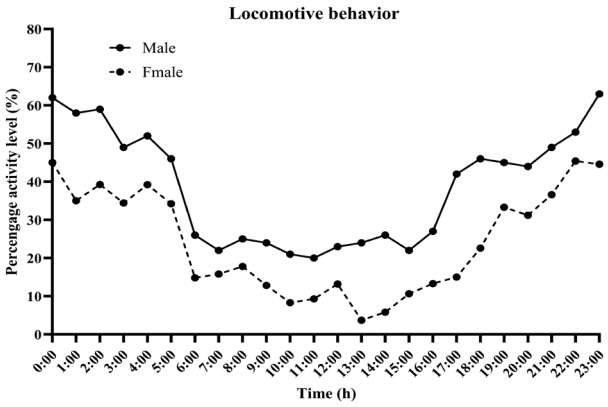

Fig. 3. Pattern of active behavior of adult male (solid line) and adult female (dashed line) leopard cat *Prionailurus bengalensis* in captivity at Beijing Wildlife Rescue Center, China.

The nursing behavior of the female leopard cat exhibited a bimodal pattern, with peak feeding times occurring between 22:00–23:00 and 00:00–01:00 (Fig. 4). The lowest frequency of nursing activity was observed between 07:00 and 12:00.

Parental behavior refers to the maternal care provided by adult female cats to their offspring. Newborn kittens are initially breastfed, begin teething around one month of age, and gradually transition to consuming fresh meat. Nursing typically takes place inside a nest box, with each session lasting more than 15 min. This behavior generally peaks during two distinct time periods: around 23:00 and 00:00.

During the daytime, the cats spent most of the time resting; they started to be active in the late afternoon (from 17:00) and were continuously active during the nighttime, with a high proportion of vigilance behaveiors (Fig. 4E, F). The level of active behavior of the cats was high at night, gradually decreasing from 05:00 on ward. Active behaviors were observed less than 20% of the time from 06:00 to 16:00.

The groom behavior category represents the cat essentially taking care of itself, providing comfort, and keeping healthy. This category is composed of six behaveiors: defecating, maintenance, urinating, stretching, scratching and clawing. The cats started maintenance behaviors in the afternoon (18:00). The highest proportion of maintenance was exhibited by the male around 23:00 to 00:00, while the female exhibited a peak at 23:00 to 00:00 (Fig. 4A).

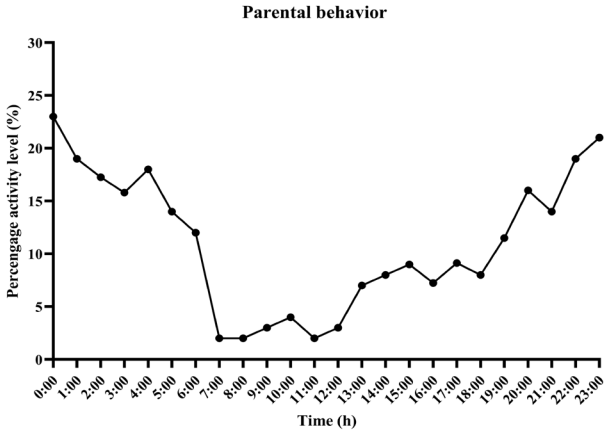

Fig. 4. Parental behavior patterns of an adult female leopard cat kept in captivity at Beijing Wildlife Rescue Center.

Signs of aggression include showing teeth, hitting, lunging and rubbing the head or body against objects inside the enclosure. During the study period, a smaller proportion of aggression categories occurred, mainly in female cats. Females are usually aggressive when defending food, territory, and young. In contrast, when males followed females for more than 10 min, females tended to act aggressively (Fig. 4D). Attacks usually occur between 15:00 and 23:00 and between 0:00 and 4:00.

In this study, the copulation behavior included any interaction between cats related to mating, such as social head rubbing, following, and napping. These behaviors occur during the day and at night, and are more common in male cats than female cats. From late afternoon to throughout the evening, there is a high proportion of interaction between the sexes. The following are present in both sexes, but are more common in male cats. The male cat usually follows the female cat for a while and then trots toward him, crouching there and crouching in front of him to signal that she is ready to mate. Mating habits occurred randomly 2-3 times per night for 2 weeks, during the evenings of the study period.

The feeding behaviors (including drinking) occurred mainly at night. The male cat actively consumed food from around 17:00. The feeding time of the female was longer

and occurred several times overnight compared to the male cat (Fig. 5E). Interestingly, male cats also fight over food with female cats.

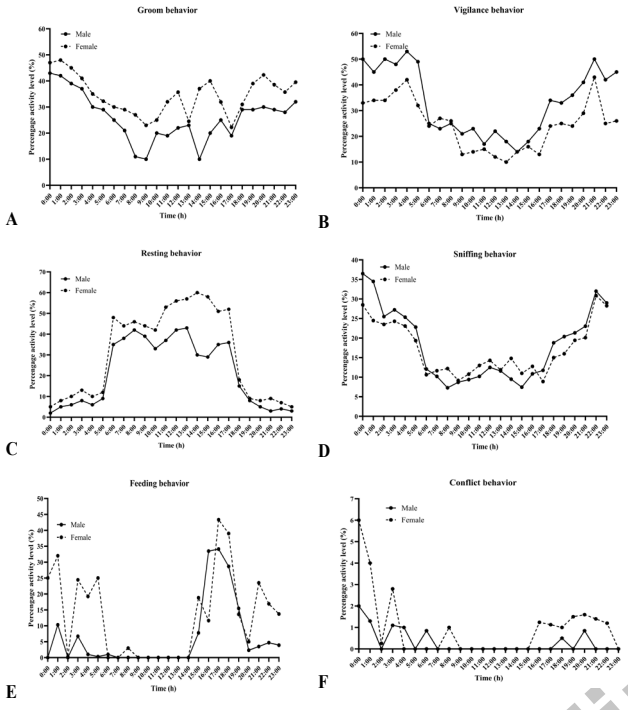

Fig. 5. Patterns of activity for all six functional categories of behavior in an adult male (solid line) and an adult female (dashed line) leopard cat *Prionailurus bengalensis*. A, groom behavior; B, vigilance behavior; C, resting behavior; D, sniffing behavior; E, feeding behavior; F, conflict behavior.

Vigilance behaviors indicate that cats are alert to their environment. This category comprises five behaviors: walking, jumping, standing, watching, and sniffing. The vigilance behaviors of the male and female were exhibited in similar patterns. The cats started displaying vigilance behaviors at 16:00, with a peak in activity at 21:00 and again around 04:00 (Fig. 5F).

Rest behavior indicates resting on the ground, and of course, it also involves looking around and not moving. Female and male cats show the same pattern of behavior. Cats begin to exhibit rest behavior at 6:00 and peak rest again around 7:00 and 12:00 (Fig. 5C).

Sniffing indicates that a cat is searching for prey or exploring its environment, and females and males show the same pattern of behavior. The sniffing behavior of the cat begins at 18:00 and peaks around 22:00 and 0:00 (Fig. 5D).

The feeding behaviors (including drinking water) occurs mainly at night. The male cat has been actively eating since around 16:00. Compared to male cats, female cats eat for longer periods of time, eating multiple times at night (Fig. 4E). Interestingly, male cats and female cats have obvious territorial, male cats will compete with female cats for food, and kill live rabbits or chickens before moving to the nest box to eat (Fig. 5E).

Signs of aggression include showing teeth, hitting, lunging and rubbing the head or body against objects inside the enclosure. During the study period, a smaller proportion of aggression categories occurred, mainly in female cats. Females are often aggressive when defending food, cubs, and territory. Ask to chase the male cat. In contrast, females tend to act aggressively when males follow females for more than 3 min (Fig. 5F). Usually, the female leopard cat will chase the male cat for more than a minute, and the female cat has a clear advantage.

Activity time budget

During the daytime, male leopard cats spent most of their time engaged in locomotive and vigilance behaviors, followed by maintenance, resting, and tempering activities, while feeding and conflict behaviors accounted for a relatively small proportion of their time. In contrast, female cats primarily allocated their time to resting, maintenance, and locomotion, with vigilance, tempering, and movement behaviors occurring at similar frequencies. Overall, male cats were more active, devoting a greater portion of their time to exercise and vigilance, while female cats spent more time resting and performing maintenance behaviors. Feeding and conflict behaviors were observed at lower frequencies in both sexes. Specifically, male cats prioritized locomotion and vigilance, followed by rest, grooming, and feeding. Female cats, on the other hand, spent the most time resting and grooming, followed by vigilance, feeding, tempering, and conflict behaviors. These differences highlight sex-specific behavioral patterns, with males being generally more active and alert, and females showing a stronger tendency toward rest and self-maintenance. The mean percentages of time spent on each behavior category are presented in Table I, and the proportional distribution of daily activities is illustrated in Figure 6.

During the daytime, both male and female leopard cats spent the majority of their time resting, being vigilant, engaging in locomotion, and performing grooming behaviors. A comparison of activity time budgets using the Mann–Whitney U-test revealed a significant difference in resting time between the sexes, with females spending a greater proportion of time resting than males ($U = 137$, $p = 0.001$). Additionally, females exhibited a significantly higher proportion of grooming behaviors compared to males ($U = 115$, $p = 0.001$).

Table I. Percentage of time (Mean±SD) spent on displayed behaviors by leopard cat in captivity. Differences between means (*) were considered significant at p < 0.05.

Behavioral category	Day			Night		
	Male	Female	P	Male	Female	P
Resting behavior	19.92±6.85	27.38±7.53	0.001	36.55±9.35	28.73±11.17	0.005
Grooming behavior	20.23 ± 6.51	30.42±5.58	0.00026	31.45±6.86	38.76±6.43	0.018
Vigilance behavior	37.15± 11.52	22.54±5.29	0.00035	40.0±14.01	24.73±7.52	0.0047
Sniffing behavior	10.49±2.10	16.70±4.06	0.00054	24.51±6.30	18.17±2.60	0.0059
Locomotive behavior	39.99±12.8	26.37±10.08	0.006	60.00±8.56	40.9±10.08	0.00012

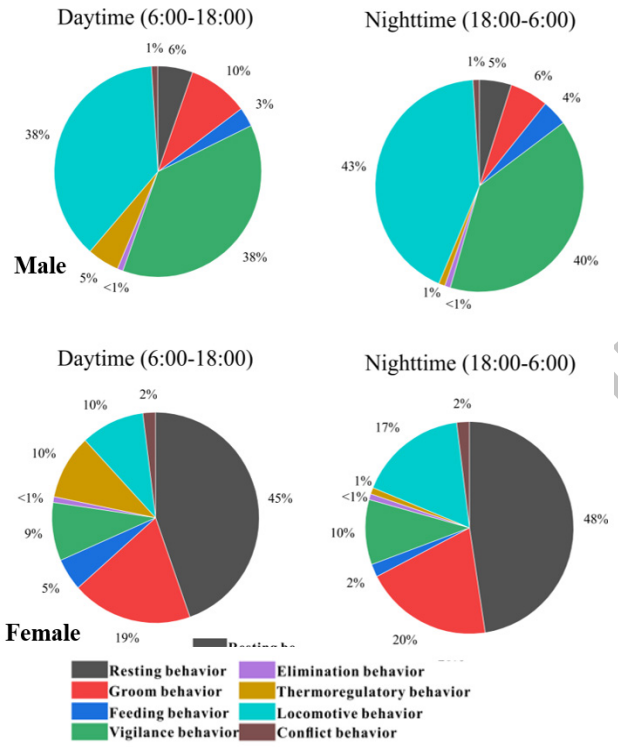

Fig. 6. Time budgets of adult male and female leopard cat *Prionailurus bengalensis* in captivity by functional category.

At night, the most common activities observed in male leopard cats were locomotion and vigilance, whereas females primarily engaged in resting and grooming. Grooming and resting followed as the next most frequent behaviors for males, while grooming and vigilance were the next most common for females. Significant sex-based differences in locomotion were observed both during the daytime (U=187, p=0.006) and nighttime (U=78, p=0.00012). Likewise, vigilance behavior differed significantly between males and females during the day (U=123, p=0.00035) and at night (U=201, p=0.0047). The average percentage of time allocated to each behavioral category is summarized in Table I, and the proportional time budgets are visually represented in Figure 6.

DISCUSSION

This study is the first to present a detailed behavioral profile of captive leopard cats (Prionailurus bengalensis) during their breeding period. Behavioral classification and descriptions were primarily based on the standardized ethogram for felids (Stanton *et al*., 2015; Liu *et al*., 2023). The cats exhibited a clear diel pattern: they spent most of the daytime resting, with increased activity during the night. Although maintenance and affiliative behaviors occurred only intermittently, they remained a consistent part of the behavioral repertoire during the mating season. Compared to the Iriomote cat *(Prionailurus bengalensis iriomotensis*), leopard cats in this study allocated more time to self-maintenance and social interaction (Schmidt *et al*., 2009). While no statistically significant sex differences were found in the percentage of time spent on maintenance behaviors (Table I), females generally devoted more time to self-care than males. Notably, male maintenance behaviors were concentrated in the late afternoon and early evening, whereas females exhibited these behaviors throughout the day.

Aggressive behaviors were rare during the mating period. Most aggression was displayed by females and was primarily related to food defense. The only aggressive behavior shown by the male was scent-marking through rubbing, interpreted as territorial signaling. Food-guarding behavior was observed exclusively in the female, likely due to maternal and resource-protective instincts. Male leopard cats showed heightened mobility in response to reproductive cues (Okamura *et al*., 2000), increasing movement and vigilance during the mating season (Fig. 4B). This activity pattern is consistent with ecological findings that males have larger home ranges and higher

activity levels than females (Ferreras *et al*., 1997; Odden and Wegge, 2005; Chen *et al*., 2016). This behavioral strategy allows males to allocate more time and energy to locating mates, defending territory, and searching for food (Herbst and Mills, 2010). The observed nocturnal and crepuscular activity may also correspond with the behavior of their prey. Males increased their activity range and movement rate during the mating period, likely to improve chances of locating receptive females. In contrast, female behavior was shaped by the demands of maternal care and food availability (Schmidt *et al*., 2009). The behavioral patterns identified here offer novel insights that may inform captive breeding programs and potential reintroduction strategies. Currently, there is limited behavioral information available for leopard cats, both in the wild and captivity. Most existing knowledge derives from camera trap or tracking data (Chen *et al*., 2016). Although this study was conducted in a controlled environment, it offers valuable baseline data for further research on this species. Future studies should include both breeding and non-breeding periods to generate a more comprehensive understanding of leopard cat behavior.

CONCLUSION

This study provides new insights into the behavioral displays of captive leopard cats. Overall, our findings indicate that the activity patterns of *Prionailurus bengalensis* in captivity are broadly consistent with those of related species such as *Prionailurus planiceps* and *Prionailurus iriomotensis*, as well as wild individuals of other small felid genera, including Felis and Leopardus. Given the limited understanding of the behavior and husbandry of rare and elusive species, studies of their daily activity particularly during the breeding period are vital for generating baseline biological data that can inform effective management strategies. Knowledge of a species behavioral repertoire and minimum husbandry requirements significantly enhances the success of captive breeding programs. Such information not only supports the recovery and welfare of captive populations but also contributes to the design of pre-release training protocols, thereby improving the likelihood of survival following reintroduction. From 2008 to 2022, the Beijing Wildlife Rescue Center's continuous monitoring recorded the rescue of 35 leopard cats, including 33 adult leopard cats and 2 semi-adult leopard cats. Among them: there were 8 cases (23%) of scratches, 5 cases (14%) of continuous impact injuries, and 22 cases (63%) in a weak state. Based on these findings, we have put forward some protection suggestions, such as: Enhance Public Awareness: Install informational signage and distribute educational materials to raise awareness among local communities about the legal protection status and ecological importance of leopard cats. Balance Conservation and Development: Restrict large-scale forest land development near mountain regions to preserve leopard cat habitats and ensure adequate food resources. Strengthen Ecological Monitoring and Wild Releases: Conduct field surveys on population size and ecological habits. Support rescue, rehabilitation, and wild release programs including the reintroduction of captive-bred individuals to boost wild populations and enhance genetic diversity. The significance of artificial breeding for leopard cats extends across ecological, scientific, and ethical dimensions. For subspecies facing severe threats from habitat loss, poaching, and environmental change, captive breeding can provide vital genetic reserves. Following proper wild acclimation and training, these individuals can be released to support the recovery of natural populations and help restore ecosystem balance.

DECLARATIONS

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IRB approval

All experimental procedures are carried out in accordance with the guidelines set out in the Regulation on the Administration of Experimental Animals (Ministry of Science and Technology of China, 2004) and approved by the Beijing Municipal Bureau of Landscaping.

Ethics statement

All experimental procedures are carried out in accordance with the guidelines set out in the Regulations on the Administration of Experimental Animals (Ministry of Science and Technology of China, 2004) and approved by the Beijing Municipal Bureau of Landscaping.

Generative AI and AI-assisted technology statement

The authors have declared that no generative AI or AI-assisted technologies were used to create this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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