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Abstract

Manis pentadactyla was once a widely distributed and resource-rich pangolin species in China. However, in recent years, the wild population has declined sharply due to overuse and habitat loss. It is currently one of the world's most endangered species and is listed as a "National First-class Protected Animal" on the IUCN Red List of Threatened Species and the China Biodiversity Red List of critically endangered species. This study recorded videos of captive *M. pentadactyla* and used “continuous animal behavior recording” to study the behavioral characteristics of this species in captive environments. The results showed that under captive conditions, behaviors of the Chinese pangolin mainly include feeding, exercise (such as crawling, digging, and climbing), mating, hiding, and resting, where the most common behaviors besides resting were climbing and pacing. Overall, the peak activity period of the pangolins falls between 18:00 and 21:00, which differs from documented activity rhythm results obtained in the wild, most likely due to the ease of acquiring food in artificial captive environments. A correlation analysis between the duration of exercise and feeding behaviors indicates a significant positive correlation between the times allocated to the two behaviors, which means that the more exercise they get, the more they eat. The mating behavior of the pangolins never lasted more than 40 minutes, and based on the time of the first mating behavior, it is estimated that the gestation period of *M. pentadactyla* in captive environments is less than 131 days. Individual A7, reported in this study, is the first *M. pentadactyla* baby born in an artificial captive environment on the Chinese Mainlandand and still alive. In addition, this study compares the captive behavior of *M. javanica* and *M. pentadactyla*, highlighting certain differences in behavioral rhythms between the two pangolin species. This work will aid in the development of captive breeding programs for the Chinese pangolin and the potential supplementation of the wild population.

Keywords: *Manis pentadactyla,* pangolin, artificial captivity, activity rhythm, behavioral

characteristics, reproduction

Introduction

The Chinese pangolin (*Manis pentadactyla*) is a placental mammal belonging to the order Pholidota, family Manidae. Among the eight existing species of pangolins, all exhibit specialized feeding habits, primarily preying on ants and termites. Characterized by their unique armor of overlapping scales, they are commonly referred to as "scaly anteaters". Pangolins play a critical role in the ecosystem by controlling insect populations and aerating the soil through their digging activities (Simpson 1945; Rose and Gaudin 2010). The Chinese pangolin is an elusive nocturnal animal, with a low population density making it difficult to observe its activity rhythm in the wild.

For most of the day, *M. pentadactyla* remains safely hidden in caves or under rocks, to rest and sleep (Pradhan and Pradhan 2020). It is a solitary animal with little socialization between individuals (Wu et al. 2020), although males may engage in territorial competition during the breeding season to secure mates and resources (Sun et al. 2020; Dudgeon and Corlett, 1994). Studies on wild pangolins are rare, but scholars have used telemetry to observe one adult pangolin and one subadult for seven days and 12 days, respectively. The results showed that they are mainly active at night, with a peak activity at dusk and activity within the cave or burrow during the day (Jiang et al. 1988). More specifically, Challender et al. proposed a wild foraging behavior spectrum of pangolins that mainly includes walking, searching, eating, digging, and pausing (Challender et al. 2012).

Manis pentadactyla can mate almost year-round, but mating mainly occurs in summer and autumn (Challender 2009), where the specific mating time may be related to climate. In 1993, the first *M. pentadactyla* were born in captivity in the Taipei Zoo, with the staff overcoming the nutritional and digestive issues associated with artificial captivity and achieving phased success (Arora et al. 2023). At the Taipei Zoo, the mating behavior of *M. pentadactyla* increases during May and June, and the cubs begin to spend a considerable amount of time exploring outside their nursing caves at about 15 weeks of age (Sun et al. 2018). However, the fact that they are still kept in a small artificial enclosure and that more information is needed on the behavior and reproduction of these animals, means that large-scale breeding is impossible. However, with the decline of wild populations, captive breeding is important for protecting pangolins from extinction (Gong et al. 2015; Yang et al., 2007). However, due to the unique behavior of these animals and their dependence on natural ecosystems, captive breeding of *M. pentadactyla* is difficult, and there are many technical obstacles (Sun et al. 2021; Yan et al. 2015).

Although studies have focused on the habitat preferences of pangolins, their behavior in captive environments has been overlooked. A comprehensive understanding of *M. pentadactyla*'s behavior is crucial for evaluating the management of captive pangolins, developing rehabilitation and wild release protocols, and potential captive breeding plans. Thus, the purpose of this study is to explore the behavioral allocation patterns of *M. pentadactyla*'s under artificial captive conditions, to better understand their survival strategies in captive environments. By studying the activity time allocation of *M. pentadactyla* in artificial captive environments, we can better understand their physiological activities such as feeding, exercise, and resting, to optimize their feeding, promote behavioral richness, and improve the success rate of captive breeding. The findings aim to provide a scientific basis for effective conservation and captive breeding of the Chinese pangolin.

Material and Methods

Experimental location

This experiment was conducted at the Zhejiang Pangolin Conservation and Breeding Research Base in Jinhua, China. The area is located in the central part of Zhejiang Province, with a subtropical monsoon climate, four distinct seasons, abundant rainfall, and obvious dry and wet seasons. The average annual temperature in Jinhua City is about 20 °C, the average annual rainfall is about 1424 mm, and the average relative humidity is about 80%. This area is suitable for the survival and breeding of *M. pentadactyla* and falls within its historical distribution.

There is a total of six compartments in the laboratory, with Rooms 1-4 measuring 6 m in length, 3 m in width, and 3.5 m in height, each serving as a separate rearing area for pangolins. Each area is connected to a glass room B1-B7 with a length of 5 m, width of 3 m, and height of 3 m to simulate their wild environment (Fig. 1). The room temperature is maintained at 28℃, and the relative humidity is maintained at 60%-70%. The glass room is enclosed with glass on all sides and on top, with small windows on the sides and wire mesh blocking the outside. A 2-meter-deep pit is dug in the center of the site, and the bottom and surrounding areas are hardened with cement and filled with loess (composed of clay and a small amount of fine sand), allowing pangolins to easily dig holes in it. Small shrubs are planted in the soil layer and regularly watered to maintain the relative humidity of the indoor environment. The glass room is connected to the respective indoor areas through doors to control the entry and exit of pangolins. The areas of Rooms 5 and 6 are 16.2 m^2 and 12.7 m^2 (Fig. 1), serving as the reproducing/offspring-rearing and isolation rooms, respectively for the captive of pangolins, and are covered with 30 cm deep loess. Each compartment is equipped with temperature control equipment (air conditioning, underfloor heating, etc.) and real-time infrared monitoring equipment to ensure that the indoor environment is suitable for pangolin activities, while continuously observing and recording the behavioral activity rhythm of pangolins throughout the day.

There is a rectangular specially made wooden crate placed in the center of each rearing room, measuring 0.85 m long, 0 75 m wide, and 0.5 m high, with a square hole on one side of the crate for pangolins to enter and exit, and it contains a small amount of straw and sand inside the crate for them to rest. A 1.5-meter-long bamboo tube is placed next to the wooden crate, and a composite paste-like feed and water are placed at the bamboo joints. The feed formula is shown in Table 1, and the feeding time is 16:30 each day, with the total time for placing feed taking no more than 10 minutes.

Research subjects

The research subjects of this experiment were seven *M. pentadactyla* individuals raised in captivity within the base (Fig. 1). Four of these were raised in the base for more than six months before the experiment, including one female (A5) and three male adult pangolins (A1, A2, and A6). The other two pangolins were two male sub-adults (A3 and A4), who were newly rescued and had been in captivity for no more than one year. The remaining pangolin was the juvenile (A7), which was born during the experiment. The basic rescue information of the experimental pangolins is shown in Table 2.

Behavioral observation

The start time and duration of each activity of the seven pangolins were recorded using the continuous animal behavior recording method. Based on captive rearing data and referring to defined behaviors (Bateson and Martin 2021; Challender et al. 2012), the behaviors were divided into three major categories and four subcategories through repeated observation and analysis of recorded data (Table 3). Except for A3, A4, and A7, the other four individuals were observed for a total of 293 days from 13 Apr 2023 to 31 Jan 2024. Among them, A5 and A6 were jointly housed in Room 6 from 13 Apr 2023 to 30 Oct 2023. Individual A7 was born on 30 Oct 2023 at 4:09 am in Room 6 during the breeding experiment. The observation period totaled 93 days from 30 Oct 2023 to 31 Jan 2024. After the birth of A7, male A6 was immediately moved from B6 to B7, due to the size limitations of artificial confinement sites and the influence of males on parenting behavior. The young pangolin (A7) and mother (A5), were raised together in Compartment 6 to observe and record parenting behavior.

Individual A3 was admitted for first aid on May 8, 2023. On 7 Sept 2023, due to diarrhea, it was sent to the animal hospital for treatment and returned to the base on 26 Oct 2023. The total observation time for this individual was thus 219 days. Individual A4 was admitted for medical treatment on 20 Jun 2023 and died on 5 Aug 2023, and the observation period for this individual was 46 days.

The excretion time of captive pangolins is very short, rarely exceeding 1 minute, so this behavior is included in the activity behavior and was not separately listed.

Data analysis

The duration of each time period's behavior is the total cumulative duration of that behavior during that time period. The allocation of behavioral time is the percentage of time that the behavior occupies in the total observation time. In the study of the activity rhythm, the 13 hours were divided into 13 time periods and the data were statistically analyzed using IBM SPSS Statistical 21.0 software. All tests were bilateral tests, with $p < 0.05$ indicating statistically significant differences. SigmaPlot 12.5 was used for plotting and visualizing the data.

Results

Activity rhythm

The daily activity time of the A1 individual was generally from 18:00 to 3:00, and their feeding behavior changed accordingly. Activity usually started with feeding, with a brief break in activity from 21:00 to 22:00, and activity gradually stopping at 2:00. The time allocated to activity behavior accounted for 11.33% of the total time while feeding behavior accounted for 7.34% of the total time (Fig. 2 A).

The activity time of individual A2 was generally from 20:00 to 4:00, with most activity occurring from 23:00 to 4:00 and activity peaking between 1:00 to 2:00 in the morning. Activity behavior accounted for 14.33% of the total time while feeding behavior accounted for 6.31% (Fig. 2 B). This individual generally spends more time on activity behavior after 1:00 every day compared to the other individuals, possibly because it preferred resting in the cave in the glass room, while other individuals preferred resting in wooden crates in the indoor compartments. The environment of the glass room is similar to the natural habitat of *M. pentadactyla*, making this individual's captive behavior more in line with that of wild pangolins. The glass room could thus also stimulate the individuals' vigilance towards the environment better, compared to the indoor compartments.

The activity time of individual A3 was generally from 16:00 to 2:00, with activity increasing between 16:00 to 21:00 and peaking between 18:00 to 19:00. Its feeding behavior showed a bimodal pattern, with peaks from 18:00 to 19:00 and from 20:00 to 21:00. Activity behavior time allocation accounted for 3.81% of the total time, while feeding behavior accounted for 2.51% of the total time (Fig. 2 C). From 7 Sept 2023 to 26 Oct 2023, A3 was sent to an animal hospital for diarrhea treatment, and as there was a lack of direct evidence indicating infection, it is speculated that the pressure of the captive environment, including improper diet, proximity to other male pangolins, the size of captive space, the presence of stereotypic behavior, and human interference may have been to blame.

The activity time of individual A4 was usually from 16:00 to 2:00, but the daily activity volume was small. The allocation of activity behavior time accounts for 7.55% of the total time, and feeding behavior accounts for 0.81% (Fig. 2 D). Since A4 was unable to feed autonomously from rescue until death, forced feeding was used. The gavage time was consistent with the feeding time of the other pangolins, both were conducted between 16:00 and 17:00 every day. After 0:00 in the morning, A4's activity gradually slowed until it stopped at 2:00 and the animal entered the wooden crate for rest. During the observation period, there was a significant decrease in the overall activity frequency of A4, until it unfortunately died on 5 Aug 2023.

The activity time of individual A5 during the childcare period was generally from 15:00 to 4:00, with a peak period between 17:00 to 19:00. Feeding behavior stopped after 3:00, and the allocation of activity behavior time accounted for 21.45% of the total time while feeding behavior accounted for 6.83% (Fig. 2 E).

Individuals A5 and A6 generally engaged in joint activity or rest during the joint feeding stage, and the activity or rest of one individual affected the other. Activity started at 17:00 and lasted until 0:00. The peak period of the activity was from 19:00 to 20:00, during which courtship behavior accounted for a large proportion of the activity. Activity behavior time allocation accounted for 13.43% of the total time, while feeding behavior accounted for 3.92%, and mating behavior accounted for 1.38% (Fig. 2 F).

Except for individual A4 who was fed by gavage, the first feeding peak of the pangolins was usually accompanied by an activity peak. The proportion of feeding behavior time accounted for 2.51% - 7.34% of the total time, and the proportion of activity behavior time to total time was 3.81% - 21.45%. Under captive conditions, *M. pentadactyla* usually starts to move after 18:00 and continues until before 4:00 the next day, with almost no activity outside the wooden crates during the rest period. The peak period of the activity occurs from 18:00 to 21:00, with 20:00 to 21:00 generally being the time when pangolins feed and excrete. The probability of activity gradually decreased after 23:00 for most captive *M. pentadactyla*, and activity usually stopped after 3:00.

A correlation analysis was conducted on the duration of activity behavior and feeding behavior among individuals A1, A2, A3, and A4 (Fig. 3), and the results showed a significant positive correlation between the time allocated to activity and feeding behaviors ($r = 0.69$, $F_{1, 54} = 49.166$, $p < 0.001$).

Reproductive behavior

During observation, the courtship behavior of the male pangolin, which occurred after feeding, was identified and recorded. This involved the male actively chasing the female or moving side by side with the female, sometimes riding on the back of the female to stimulate her mating response. This reduced his appetite and increased his activity. During mating, the male and female pangolins lie on the ground with their abdomens facing each other, and their tails intertwine. At this time, the male would lick the female pangolin's abdomen or scratch her tail. The duration of the male's courtship behavior never exceeded 40 minutes, with the longest mating behavior not exceeding five minutes and the shortest being less than 2 minutes. Courtship behavior was concentrated between 19:00 and 23:00 (Fig. 2 F) and was first observed on 16 Jun 2023, and continued until 6 Sept 2023. During this period, a total of 89 matings were observed, with no mating on five days, two matings on 11 days, and one mating per day on the rest.

Offspring -rearing behavior

Due to the possibility of abandonment by the female, we did not weigh individual A7 at birth. A few days after birth, the baby pangolin was actively searching for milk, feeding more frequently with short feeds. With time, the number of feeds decreased with an increase in duration. After the first week of birth, the baby pangolin curled up in the arms of the female pangolin for longer periods. Except for climbing onto the tail of the female pangolin to move and search for milk, most of the infant's time was spent in a curled-up state. A week later, the baby pangolin not only engaged in seeking milk and feeding but also stood and walked for small distances, although this is speculated to be a form of imitative behavior. Before the end of the observation phase, the baby pangolin (93-days-old) was able to follow the female pangolin and did not need to ride on her back, but it could not truly feed freely and still needed to breastfeed. Weight measurements of the mother and baby pangolins began 66 days after birth. Starting on January 5, 2024, weights were taken every 10 days, and the baby pangolin's weight increased as expected, indicating good growth (Fig. 4). The different captive behaviors of *M. pentadactyla* are shown in Fig. 5.

Discussion

Similarities and differences between captive and wild pangolins

At present, only Ta et al. have used the maximum entropy niche model (MaxEnt) to predict the potentially suitable habitats of *M. pentadactyla* in the wild (Ta 2021), This technology is not only useful for artificial habitat construction but also for microhabitat modelling, where the environmental factors of the wild microhabitat of *M. pentadactyla* can be analyzed in combination with infrared camera recordings of the wild burrow and the findings can be applied to improve the suitability of the captive microenvironment for the pangolin. In this experiment, the behavioral habits of captive pangolins were similar to those of wild pangolins, both of which are nocturnal, with notable exceptions. In captivity, except for a few individuals, most pangolins started feeding within 1.5 hours before or after the placing of food, where the duration of feeding was relatively short without significant seasonal changes. In the wild, the foraging times of pangolins are more varied, possibly because the range of activities of captive pangolins is relatively small, while the activities of wild pangolins are more varied and individuals may migrate between different habitats (Lin et al. 2015). Additionally, the food for captive pangolins is usually provided by humans at regular intervals and is relatively limited, while wild pangolins need to search for their food in ant or termite nests, and their food sources are more diverse and abundant and may be affected by seasonal and environmental changes (Gao et al. 2024). Also, captive pangolins may have more contact and interaction with humans or other pangolins, while in the wild they are usually solitary animals whose social behaviors are more related to reproduction and territory (Chang 2004). Finally, the reproduction of captive pangolins is subject to human management and intervention such as controlling mating time, with the primary goal of ensuring successful reproduction and survival of the young. Alternatively, reproduction in wild pangolins is influenced by the natural environment and seasons, with pangolins relying on natural selection and adaptation to find and secure a mate and offspring. In summary, the behavioral patterns of captive and wild Chinese pangolins are different, and it is vital to conduct a detailed analysis of captive behavior to better facilitate artificial captive breeding.

Behavioral comparison with *M. javanica*

Wang et al. studied the behavioral patterns and allocation of *M. javanica* under mixed feeding conditions and found that feeding and resting comprised the highest proportion in behavioral time allocation, which differed significantly from the behavioral patterns of *M. pentadactyla* obtained in this study. Mostly, the feeding behavior of *M. pentadactyla* had the lowest proportion. Importantly, mixed feeding was very effective in reducing the stereotypic behavior of *M. javanica* (Wang 2015; Yan et al., 2015). However, due to the solitary and burrowing habits of *M. pentadactyla*, mixed feeding may not be suitable in captivity. Therefore, compared to *M. javanica*, this study identified more frequent stereotypic behavior. From their research results, *M. javanica* was very active from 19:00 to 06:00 the next day, compared to the peak activity period between 18:00 and 21:00 observed for *M. pentadactyla* here. In addition, we found that compared to *M. javanica* that enjoys climbing, curling up on cat racks or fallen wood, and lying on top of wooden boxes, *M. pentadactyla* prefers to dig burrows in the loess to hide.

Reproductive behavior and pregnancy of pangolins

The Chinese pangolin is difficult to breed in captivity due to its uncertain sexual maturity time, low reproductive success rate, the birth of only 1-2 babies at a time, and a high progeny mortality rate (An et al. 2023; Wanget al. 2024; Zhang et al. 2016). On the other hand, weakened immunity in captivity, and lack of understanding of their wild social behavior, foraging ecology, and reproductive behavior may have led to caretakers not providing the right environment and nutrition, resulting in the inability of *M. pentadactyla* to grow healthily in captive environments. Knowledge of pangolin breeding biology is limited, being constrained to fragmentary reproductive records including birth records of individuals at rescue stations and autopsy records of a few stillbirths (Wright 2010; Yang et al. 2007). Therefore, the reproductive parameters of pangolins are uncertain. Chen et al. discussed the activity patterns of the *M. pentadactyla* born in Taipei Zoo (Chen et al. 2005), while Lim et al. studied the reproductive behavior of wild *M. javanica* identifying their diurnal activity patterns, nest usage at birth, and the home range of a female pangolin released into the wild (Lim and Ng 2008). However, there are few reports on the reproductive traits of pangolins including birth time, estrus and pregnancy period and litter size. This is the first study to date on the mating and breeding behaviors of captive *M. pentadactyla* on the Chinese Mainland.

Normally in the wild, *M. pentadactyla* are solitary except during mating season, which peaks between May and July. Their belly-to-belly mating is different from that of other mammals, so their mating usually occurs outside the burrow in the wild. During mating season, male pangolins often compete with each other for females and the winner will mate with the female, where the mating period generally lasts for 3 to 5 days (Sharma et al. 2020). Different species of pangolins have different gestation periods, for example, *M. tetradactyla* and *M. tricuspis* have a gestation of about 139 days (Van 1966), while *M. crassicaudata* has a relatively short gestation of 65-70 days (Hayssen et al. 1993). The pregnancy period of *M. pentadactyla* is about 101-169 days (Sun et al. 2020), which is consistent with the observations of this study of 131 days. Chin et al., by monitoring the concentration of serum progesterone hormone, concluded that the pregnancy period of *M. pentadactyla* is 318-372 days (Chin et al. 2012), which is significantly different from the findings in this study. This may be because under captive conditions, food is more abundant and the living environment is safer, resulting in a shorter pregnancy for *M. pentadactyla*.

Conclusions

The wild habitat of *M. pentadactyla* contains key ecological factors such as the burrow and surrounding microenvironment, temperature, air humidity, soil moisture, and burrow structure characteristics, etc., that are used to model and improve the captive environment parameter system of *M. pentadactyla*. Although this study is the first to successfully breed *M. pentadactyla* on the Chinese mainland in an artificial captive environment, there are still many technical challenges to the captive breeding of pangolins. Due to low population numbers and the constant poaching threat, successful captive breeding programs are vital for the survival of the Chinese pangolin, and based on our experience, we suggest the following improvements and suggestions:

(1) Improve the environmental parameters of the captive environment using habitat modeling to simulate the natural habitat in the wild, as this is one of the reasons for the poor adaptation of *M. pentadactyla* to the artificial captive environment. (2) Artificial feeding volume and frequency adaptations need to be made. Compound feed was used to feed the captive pangolins in this study, but the body weight of the studied individuals was too high. It is speculated that because compound feed is suitable for rescuing individuals who need additional nutrition due to starvation or neglect, the ratio of the feed should be properly adjusted after the animals have regained their health, to ensure that pangolins can maintain a normal weight while receiving adequate nutrition. (3) Disease control and innate immunity in captivity need additional attention. We found that *M. pentadactyla* often suffered from diarrhea, a runny nose, and other diseases, which could be improved with optimal temperature and humidity conditions, a healthy and more diverse diet and regular deworming, to reduce the stress response of captive individuals. Concurrently, disease research should be increased, and the causative agents should be identified through a biosafety system, hierarchical health examination, and pathological research. Furthermore, a prevention and control program for common pangolin diseases should be established for the expedited treatment of similar future cases.

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Figure captions

Fig. 1 Layout of captivity site of Chinese pangolins for behavioral study and the seven Chinese pangolin research subjects of this study (A) A1; (B) A2; (C) A3; (D) A4; (E) A5 and A6; (F) A5 and A7.

Fig. 2 Duration of day and night activity (Left) and percentage of behavioral time allocation in captive *M. pentadactyla* (Right). (A) A1; (B) A2; (C) A3; (D) A4; (E) A5 offspring-rearing stage; (F) A6 cage closing stage.

Fig. 3 Correlation analysis between the duration of movement and feeding behaviors of *M. pentadactyla*.

Fig. 4 Weight changes in *M. pentadactyla* during the childcare period.

Fig. 5 Different captive behaviors of *M. pentadactyla* (A) Climbing; (B) Digging; (C) Feeding; (D) Chasing; (E) Climbing to courtship; (F) Mating; (G) Breastfeeding; (H) Childrearing; (I) Female pangolin and cub (by Zhenhui Shen, 4 Jan 2024).

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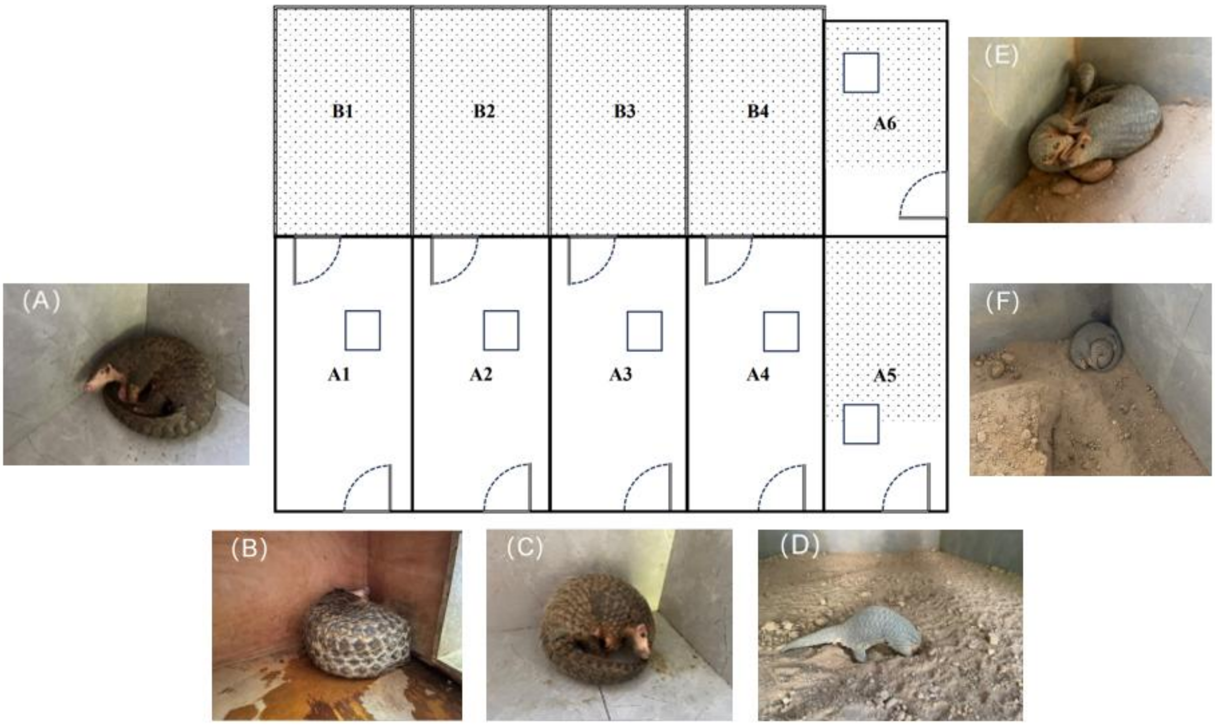


Fig. 1

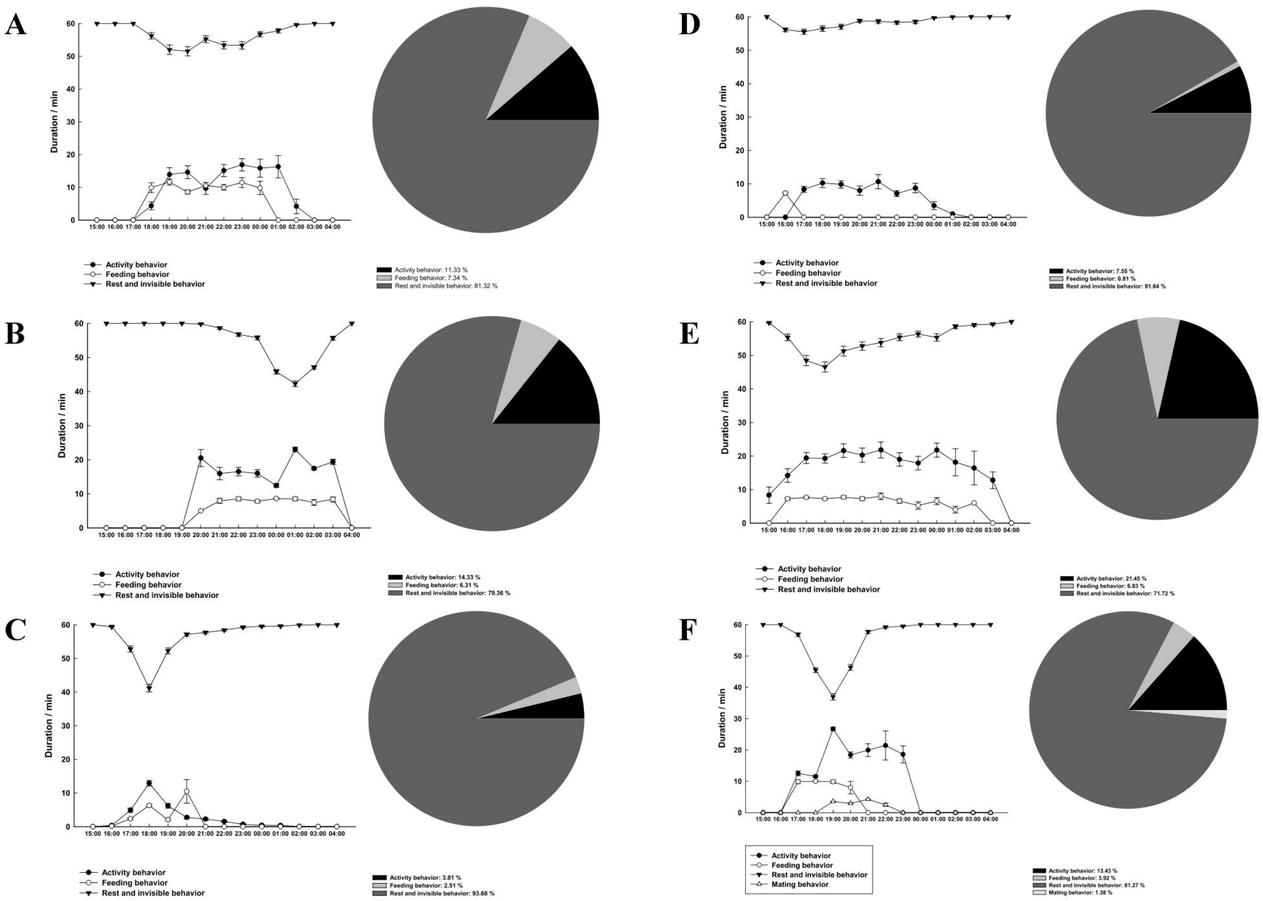
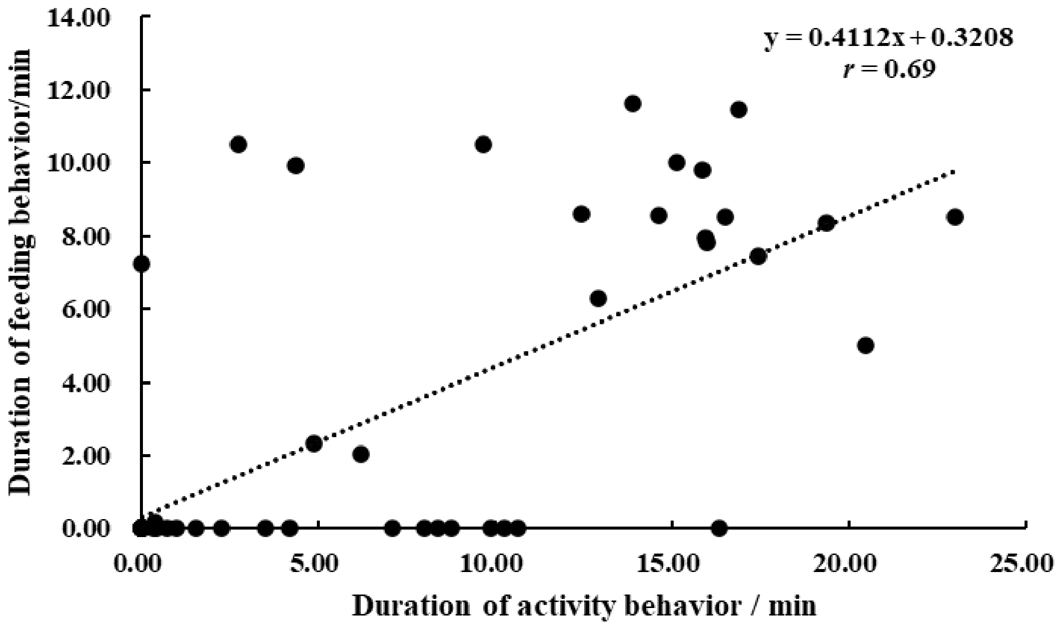
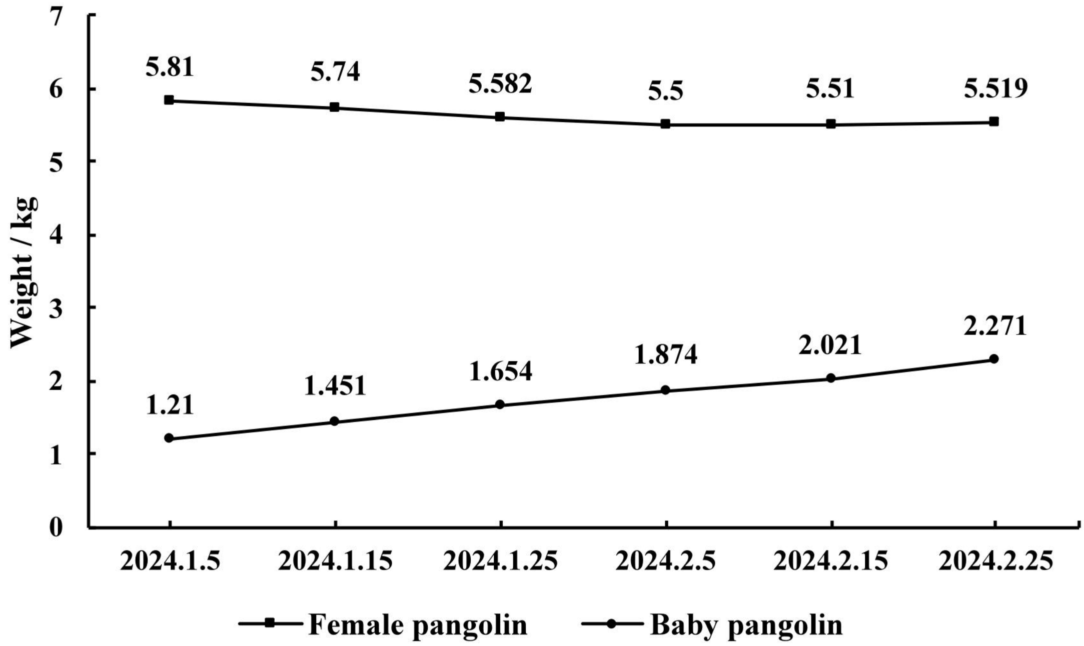

A
B
C
D
E
F
Duration / min
15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00
Activity behavior
Feeding behavior
Rest and invisible behavior
Mating behavior
Activity behavior: 11.33 %
Feeding behavior: 7.34 %
Rest and invisible behavior: 81.32 %
Activity behavior: 14.33 %
Feeding behavior: 6.31 %
Rest and invisible behavior: 79.36 %
Activity behavior: 3.81 %
Feeding behavior: 2.51 %
Rest and invisible behavior: 93.68 %
Activity behavior: 7.55 %
Feeding behavior: 0.81 %
Rest and invisible behavior: 91.64 %
Activity behavior: 21.45 %
Feeding behavior: 6.83 %
Rest and invisible behavior: 71.72 %
Activity behavior: 13.43 %
Feeding behavior: 3.92 %
Rest and invisible behavior: 81.27 %
Mating behavior: 1.38 %

Fig. 2



y = 0.4112x + 0.3208
r = 0.69
Duration of feeding behavior/min
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
5.00
10.00
15.00
20.00
25.00
Duration of activity behavior / min

Fig. 3



Weight / kg
7
6
5
4
3
2
1
0
5.81
5.74
5.582
5.5
5.51
5.519
1.21
1.451
1.654
1.874
2.021
2.271
2024.1.5
2024.1.15
2024.1.25
2024.2.5
2024.2.15
2024.2.25
Female pangolin
Baby pangolin

Fig 4

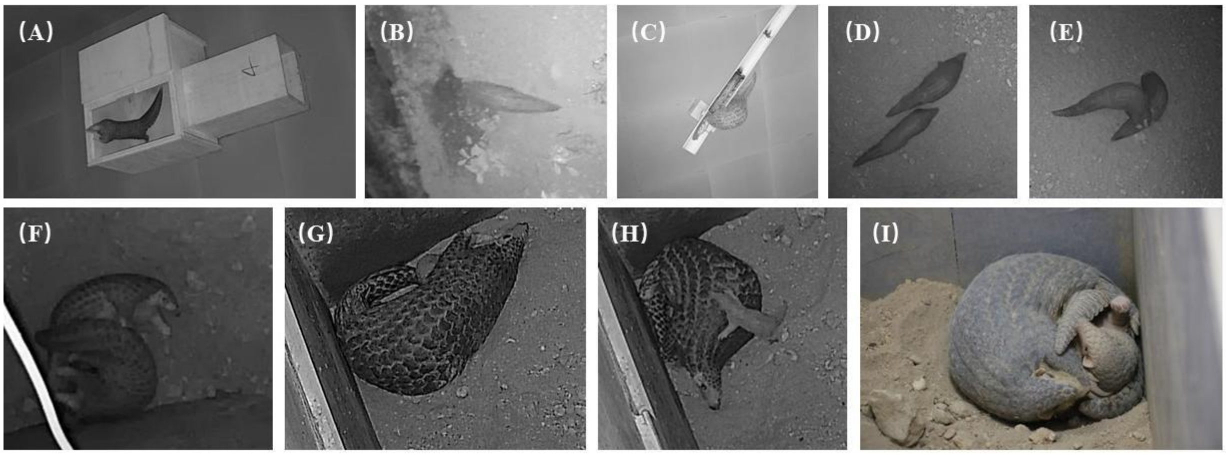


Fig. 5

Table 1 Composition of compound feed for *M. pentadactyla*

Ingredients	Cat food	Dried *Tenebrio molitor*	Dried *Polyrhachis vicina*	Water	Milk powder	egg yolk
Content / g	137.5	52.5	90	500	3.75	15

Table 2 Basic rescue information of seven *M. pentadactyla*

Individual	Gender	Rescue area	Rescue time	Remarks
A1	Male	Shaoxing Shengzhou Zoo, Zhejiang, China	2021.8.20	Adult
A2	Male	Lanxi City, Jinhua City, Zhejiang, China	2021.7.3	Adult
A3	Male	Baishanzu Nature Reserve in Lishui, Zhejiang, China	2023.5.8	Subadult
A4	Male	Qingtian County, Lishui City, Zhejiang, China	2023.6.20	Subadult
A5	Female	Longyou County, Quzhou City, Zhejiang, China	2022.7.30	Adult
A6	Male	Wenzhou Green Eye Ecological Protection Center, Zhejiang, China	2021.5.7	Adult
A7	Female	Autonomous artificial breeding	2023.10.30	Juvenile

Table 3 Classification of behaviors of captive *M. pentadactyla*

Behavioral categories	Behavioral subcategories	Specific behaviors
Visible behavior	Feeding behavior	Feeding
		Drinking
	Activity behavior	Climbing
		Crawling and Pacing
		Excavate
		Pause (sniffing, standing, etc.)
		Excretion
		Matchmaking (climbing back, chasing, etc.)
	Mating behavior	Mating
Invisible behavior	Hidden behavior	Excavation inside the tunnel
		Concealment (inside the wooden box)
Rest	-	Lying on one's side, curling up, entering the hole, etc.