

# Observation on Binturong (*Arctictis binturong*) behaviour and its conservation management practices at Semarang Zoo, Central Java

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**Abstract.** The purpose of the study was to observe behaviour daily and investigate its management practices at the Semarang Zoo. Scan sampling was used to monitor the behaviours of three solitary binturongs in 3.0 x 1.5 m enclosures which reflected their solitary nature. Diurnal observations revealed that binturongs spent over 50% of their time sleeping and resting, consistent with their nocturnal habits. A daily diet of papaya, banana, cucumber, and chicken meat was provided to support their lives. Management strategies such as daily enclosure cleaning, freshwater supply, and health care every three months were implemented. It suggested that welfare could be enhanced by adding enrichment activities and increasing the variety of diets. Observations during daylight hours highlighted the need for further studies on both diurnal and nocturnal activity patterns. Conservation institutions believed that research on phylogenetics and genetic diversity of binturongs was critical for effective species conservation. Based on detailed observation and analysis, it was found that effective management practices significantly improved the welfare of captive binturongs. These findings provide essential insights into binturong behaviour and care, the development of best practices for zoo management as well as support for the ongoing conservation initiatives.

## 1 Introduction

Binturong (*Arctictis binturong*) also known as the bearcat is classified as a mammal. This species belongs to Viverridae family, which comprises civets or luwaks. It is recognized as one of the largest - civet species. Thick black fur with silver tips, whiskers, and a tail almost as long as its body characterize the binturong. The binturong's tail possesses unique characteristics, with a muscular base and a prehensile tip that can be extended [1]. Binturong is typically found in tropical and subtropical forests in Southeast Asia, including India, Nepal, Bhutan, Thailand, Malaysia, and Indonesia. Nine subspecies were identified within the binturong. The subspecies *A.b. binturong* is found in Malacca (Malaysia). *A.b. albifrons* is

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distributed in Tonkin (North Vietnam). *A.b. whitei* is located in Palawan (Philippines). *A.b. pageli* is present in Sandakan (North Borneo). *A.b. gairdneri* is found in Siam (North Thailand). *A.b. niasensis* is distributed on Nias Island (West Sumatra). *A.b. penicillatus* is located in Java (Indonesia). *A.b. kerkhoveni* is found on Bangka Island (East Sumatra), and *A.b. menglaensis* is distributed in Yunnan Province (China) [2, 3].

A comprehensive field investigation has never been conducted on the binturong [4,5] especially in the natural habitat, even though some researchers have described binturong as semi-arboreal animals. Among carnivorous animals, aside from the binturong, the kinkajou, often referred to as the "honey bear" is identified as the only other species with a fully extendable tail [2,6]. Most of its time is spent climbing trees and sleeping on branches. A pandan or screw pain scent is emitted from glands located under the base of its tail which is used to mark its territory [7]. The binturong's diet is composed of a variety of foods such as fruits, insects, eggs, fish, birds, shoots, and leaves. According to [8] fruits from the *Ficus* species are predominantly consumed by binturongs in their natural habitat in Palawan.

The population of binturongs in Indonesia, as well as in several other Southeast Asian countries, has declined significantly due to habitat loss and illegal hunting. The loss of tropical forests due to land conversion for agricultural purposes, forest encroachment, and deforestation has reduced the natural habitat. Illegal hunting for animal trade and the consumption of fur and meat remains a serious threat to the binturong population. These activities further fragmented and degraded the binturong's remaining habitat, making it even more difficult for the species to survive. The binturong has been assessed as a vulnerable species by the IUCN Red List, with a potential population decline of 30% over three generations. They are also threatened by illegal trade, use in traditional medicine, and hunting for their meat and fur. Binturongs are protected species in Indonesia based on The Indonesian Ministry of Environment and Forest regulation number 106 in 2018 [1, 9, 10].

The vulnerable binturong species are conserved in zoos. Its safe habitats, the promotion of breeding programs, and public education are implemented. The appropriate management of binturongs in zoos is very crucial for their well-being and it contributes to global conservation initiatives. Access to an appropriate diet, enrichment activities, and veterinary care must be ensured for binturongs to maintain their physical and mental health. The behaviour, health, and reproductive success of binturongs in zoos were monitored and recorded, allowing valuable data to be gathered by conservationists. These data are used to inform future management strategies and contribute to the overall survival of the species. Ultimately, the long-term viability of binturongs in the wild is ensured through the collaboration between zoos, researchers, and conservation organizations [10].

Semarang Zoo is located in Semarang City, Central Java. The precise location is between Semarang and Kendal Cities. This place has been relocated several times because of its vast land area, difficult accessibility, and natural disasters. The zoo, with an area of over 10ha, houses approximately 40 species, including mammals, reptiles, and birds [11]. There are only four binturongs in Semarang Zoo. The animal included three adult males and one adult female. The maintenance of binturongs is housed solitarily due to their aggressive behaviour when kept together in one enclosure, especially among adult males.

The primary objective of the zoo should not be viewed as an entertaining showing wild animals. The purpose of the zoo's existence needs to be fulfilled. -Modern zoos must acknowledge that their animals are kept in enclosure when they should be in the wild [12]. Based on Minister of Forestry Regulation number 53 year 2006 regarding Conservation Institutions, it is explained that zoos have a primary function in conducting efforts for the care and breeding of various species based on ethical principles and animal welfare standards to form and develop new habitats, as a means of protection and conservation of species through rescue, rehabilitation, and natural reintroduction, and utilized as a means of education, research, scientific and technological development, and healthy recreation. In

captivity, an animal's welfare is dependent on the environment provided for them, as well as the daily care and veterinary treatment they receive. It is therefore very important that we understand their behavioural and physiological needs so we can meet them in captivity [13]. The purpose of this study was to investigate the binturong daily behaviour when kept in captivity and examine the management practices implemented at Semarang Zoo.

## 2 Methodology

### 2.1 Data Collection

Observations and data collection on management practices and behavioural studies were conducted in the binturong and civet enclosures. The data management practices collected were enclosure, diet, and veterinary care. Preliminary observations and habituation were carried out over two days, from October 24<sup>th</sup> to 25<sup>th</sup>, 2023, while daily behavioural observations were conducted over five days, from October to November 2023. The daily average temperature during the observations ranged from 32.7°C to 33.5°C, with clear weather.

Observations of management practices and behaviour of binturongs at Semarang Zoo were conducted on three male binturongs. Each of these was housed in individual enclosures. Descriptions of each binturong individual that was used as the observation subjects are presented in Figure 1. The equipment used in the observations consisted of data collection sheets, writing tools, time recorders, and cameras.



**Fig. 1.** Three binturongs were selected as research subjects.

### 2.2 Procedure and Data Analysis

Data management practices were obtained through direct field observation, and interviews with the keepers, and veterinarians. Observations are adjusted to the working hours of the zoo from 8:00 a.m. to 3:00 p.m. An Ethogram list was compiled by the researcher before daily behavioural research was conducted, collected from literature studies, particularly those related to binturongs (Table 1). Behavioural data were collected for five days, from 09:00 am to 03:00 pm using scan sampling [14]. Daily activity data was recorded as a "point sample" every two minutes, resulting in a total observation time of 1,800 minutes.

The data were analyzed descriptively and qualitatively, while the behavioural data were processed by using Microsoft Excel program in table form. The data were displayed as diagrams and graphs.

**Table 1.** The Ethogram of Binturong's daily behaviour

Active/ Inactive	Behaviour	Description
Active	Feeding (Fe)	Eating food or drinking water.
	Grooming (Gr)	Scratching, licking or rubbing on objects inside an enclosure.
	Social Interaction (Si)	Behaviour that involves any form of interaction with specific. Social interaction is divided into two affiliative or aggressive.
	Sniffing (Sn)	The behaviour of pressing the nose to a particular area, and inhaling air can be seen from the movement of the nostrils.
	Travelling (Tr)	Moving behaviour from one surrounding area to another. Including climbing and crossing ropes, and branches or moving quadrupedally along a floor or flat surface.
	Vigilance (Vi)	Behaviour responsive to stimuli, looking around observing an environment or an eye that is actively focused on a particular direction
Inactive	Defecation (De)	Defecation and urination
	Rest awake (Ra)	Behaviour that indicates an open eye, but an animal is not moving and does not indicate a behaviour of alertness or active vigilance.
	Rest (Re)	Behaviour that indicates closed eyes, relaxed body and no movement

### 3 Results

#### 3.1 Enclosure

Binturongs are housed solitarily in the Semarang Zoo (Figure 2). Each individual was placed in one enclosure measuring approximately 1.5 meters in length and width and about 3.0 meters in height. The frame of the enclosure was composed of iron and wire. Feeding and water containers were provided to each enclosure. Enrichment in the enclosures included wooden rods or boards for resting and climbing. The floor is made of concrete and designed for easy cleaning.

The binturong enclosure in the Semarang Zoo features an open design that allows visitors to see the animals. However, an overly open enclosure is less comfortable for binturongs to rest. Enclosures for binturongs are constructed by several zoos with more enclosed conditions, such as Ragunan Zoo. The enclosure is comprised of a concrete wall, with boards or wood incorporated for climbing, and small dens for hiding during the binturongs' sleeping and resting. The enclosures are also designed to be as natural as possible, with live plants planted inside or in garden pots [15].

The binturong enclosure at Taronga Zoo Sydney is also an exhibition area. The exhibit comprises an open-plan enclosure measuring 19m x 9m, enclosed by a 1.5-meter-high marine-quality plywood-panel wall. The rear wall is constructed of mock rock, featuring two strands of electrified wires along the top. Two shelter boxes are provided at a height of 2.1 m above the ground. Climbing features include dead tree branches strategically positioned throughout the space, with a large live Port Jackson fig tree (*Ficus rubiginosa*) serving as the central feature [16].



**Fig. 2.** The binturong's enclosure in the Semarang Zoo.

### 3.2 Diet

According to [12] the nutrition provided to the animals should closely resemble the diet consumed by them in their natural habitat. A balance between underfeeding an animal and overfeeding it must be maintained in every diet. A varied diet, consisting of more than one kind of food, must be given to every animal. By being given a varied range of food, animals develop a broader diet and become accustomed to eating multiple types of food. This can be helpful when a particular type of food is unavailable for a long period of time. When animals are fed a well-balanced diet, better health is experienced, a higher rate of reproduction is observed, and the young have a better chance of survival.

The binturong was fed daily, once in the morning between 09:00 and 10:00 AM. The type of feed given includes fruits such as bananas and papayas, which are peeled and cut into pieces, as well as meat such as chicken feet or chicken heads, provided three times a week (Figure 3). The feed, in terms of both quality and quantity, was given ad-libitum and was based on recommendations from nutrition experts and veterinarians. The quantity of food given was approximately 10% of the body weight.

The feeding of binturongs at Ragunan Zoo was not significantly different. The types of food provided include 4 kg of bananas and papayas that have been peeled and cut into pieces, as well as 14 hard-boiled chicken eggs that have been peeled. The hard-boiled eggs are given only twice a week. Raw chopped chicken meat is also provided once a week, and vitamins are given once a month [15]. The Taronga Zoo in Sydney provides a diet ranging from 2 to 8 kg of an omnivore mix, which includes apples, bananas, pears, grapes, kiwi fruit, sweet potatoes, and rock melons. This quantity of food is divided into two portions and is fed in the exhibit in the morning and the afternoon. Predamax multivitamin powder was added to the fruit at a dose based on the combined weight of the Binturong (5 g per 20 kg of body weight). Protein is fed in the dens early each morning and includes chicken, rabbit, horse meat, egg, kibble, and weaner rat [16].



**Fig 3.** The diet of Binturong at Semarang Zoo.

### 3.3 Veterinary Care

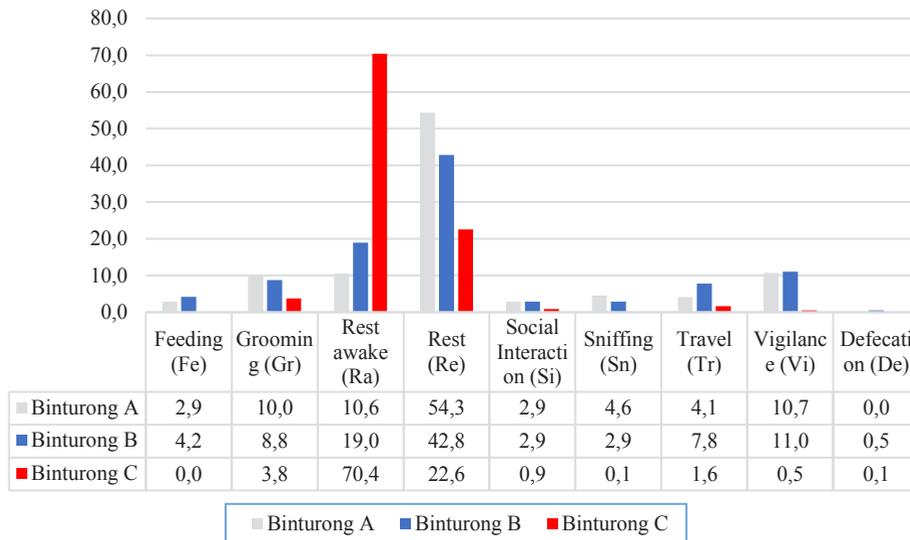
Daily interactions, such as enclosure cleaning, feeding, and routine observation are performed by keepers. Health checks are conducted by a veterinarian every three months, including health checks, treatments, vitamin supply, and endoparasite or worm examinations. According to [12] Regular observation is a vital aspect. Usually, sick or injured animals exhibit unusual behaviour compared to their usual condition. By attentively monitoring each animal under their care daily, the keepers can immediately identify any unusual activity. An animal's behaviour, such as being passive or not eating, can be indicative of an underlying issue. Identifying these indicators promptly allows for an immediate request for a veterinarian to investigate the situation.

### 3.4 Daily Behaviour

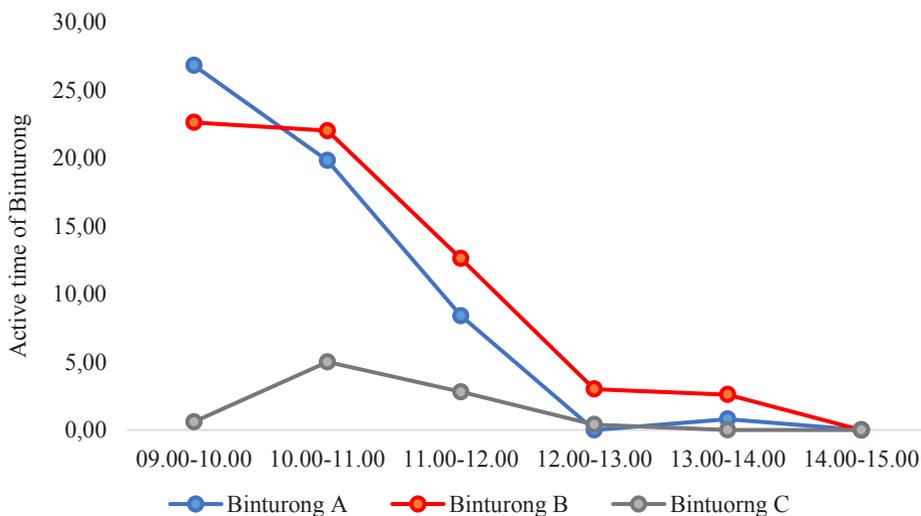
The results of our observations indicate that nine behaviours were observed in the binturong. Based on the research by [5], the behaviour of captive binturongs is categorized into two types: active and inactive. Active behaviours include feeding, grooming, social interaction, sniffing, traveling, vigilance, and defecation. Inactive behaviours include resting awake and sleeping. The observation results in Figure 4 indicate the percentage of binturong activities observed from 09:00 am to 03:00 pm over five days of observation.

The highest frequency of sleeping or resting behaviour was observed in individuals A and B (54.3% and 42.8%, respectively), followed by resting awake behaviour (10.6% and 19%, respectively). Meanwhile, in individual C, resting awake behaviour (70%) was observed more frequently compared to sleeping behaviour (22.6%). The same research results were demonstrated by [15] in the observation of binturongs at Ragunan Zoo, indicating that daily behaviour was dominated by resting behaviour. Mammals frequently engage in resting behaviour during daylight hours due to the high temperature, causing them to look for shelter under trees or in protected areas to rest. This practice involves reclining in several postures, with the eyes closed or awake [17].

Time usage (Figure 5) shows that binturongs engage in activities such as eating, interacting with keepers, and enclosure cleaning starting at 09:00 in the morning. This activity then decreases and reaches its peak at 12:00, mostly used for sleeping. The active time usage in binturongs A and B shows no difference, while binturong C exhibits different behaviour. Binturong C shows a lower active time compared to binturongs A and B. According to the keeper, Binturong C shows active time during the night. This study did not conduct night observations, so it is possible to show the active time of binturong C.



**Fig 4.** The percentage of daily behaviour observed in three binturongs.



**Fig 5.** Comparison of active time in three binturong individuals.

The observation of behaviour during daytime activities is dominated by inactive behaviour because binturongs are nocturnal animals active at night. Inactive behaviour is divided into two categories: resting behaviour, which is shown by not engaging in any activity but still being awake, and resting behaviour, which is indicated by complete rest or sleep. The percentage of resting behaviour in the three individual binturongs shows 10.6% and 19.0% for binturongs A and B, respectively. This percentage was smaller compared to binturong C (70.4%). Binturong C exhibited a unique behaviour by spending most of its time resting while hanging on the cage wall and displaying defensive behaviour towards the other two binturongs. However, it is also occasionally found resting on wooden boards like the other individuals. The percentage of rest or sleep was shown to be 54.3% for binturong A,

42.8% for binturong B, and 22.6% for binturong C. The percentage of time used for eating and drinking behaviour was recorded as 2.9% for individual A, 4.2% for individual B, and 0.0% for individual C. Food was served ad-libitum from 9 a.m. to 11 p.m. According to observations, the feed served was usually consumed directly by individuals A and B. Unlike individual C, no food or drinking activity was observed. According to the keeper's explanation, the animal, or individual C, consumes food at the beginning of the day. The eating behaviour observed in individuals A and B indicates the habit of consuming the banana or papaya first, with the meat (chicken head) being consumed last if served. According to [5,18] a natural crepuscular activity pattern is exhibited by binturongs, which implies that relaxation tends to occur during the hours when visitors are present.



**Fig. 6.** Feeding behaviour in binturongs.

Grooming activity (Figure 7a.) is defined as the activity of scratching, licking, or rubbing on objects inside a cage. The grooming behaviour of the binturong is carried out as self-care by licking and scratching parts of the body, and it is performed using the back leg or the tongue. The presentation of grooming activity was 10.0%, 8.8% and 3.8% in binturong A, B, and C, respectively. According to [15], The grooming behaviour of binturongs is performed to alleviate the itchiness caused by insects. Grooming is defined as the act of scratching, licking body parts, wagging the tail, and cleaning the ears. Grooming activities are engaged in by binturongs in a manner similar to that of cats, involving the licking of their own hair and body, licking the bodies of other individuals, scratching itchy areas with their hind legs, and rubbing their bodies against objects. Grooming behaviour is performed only at specific times, such as during breaks and while in motion.

The management approach implemented by Semarang Zoo facilitates social interaction between individuals (Figure 7b and 7c). Social interactions are frequently observed in binturong A and B, largely dominated by agonistic behaviour involving aggression or mutual aggression between individuals. The percentage of social interactions in binturongs A and B was 2.9%, whereas C exhibited only 0.9%. Interactions between Binturong B and A are frequently observed by Binturong C, but involvement is typically avoided. Solitary lives are typically led by binturongs in their natural habitat, resulting in few and intense social interactions. Generally, they life alone or with a mate throughout the breeding season, and solitary interactions are engaged during feeding or mating events.



**Fig. 7.** Grooming (A) and social interaction (B and C) behaviour.

The behaviour of sniffing in binturongs was observed through nose movements (Figure 8a). This behaviour was evident when they were searching for food or adjusting to their environment. Binturong heavily relied on their keen sense of smell to find food. Sniffing the air to detect the presence of food, whether it involved fruits, insects, or small vertebrates, was observed in them. Besides serving the purpose of food foraging, this habit also played a role in inter-individual communication. The scent was used by binturongs to mark their territory or signal to fellow binturongs, including the detection of pheromones in the search for mating partners. The percentage of sniffing behaviour was 4.6% in binturong A, 2.9% in binturong B, and only 0.1% in binturong C.

Moving behaviours (Figure 8b and 8c) observed in binturongs include walking on boards or wooden structures, climbing on enclosure walls, walking on the enclosure floor to find food and water, and engaging in defecation activities. Walking behaviour was more frequently observed in binturongs A and B, with percentages of 4.1% and 7.8%, respectively, while in binturong C, the movement activity was at 1.6%.



**Fig. 8.** Sniffing (A) and travelling behaviour (B and C).

Vigilance behaviour, which aids in survival and the avoidance of potential threats, was also prominent in binturongs. They regularly monitor their surrounding environment to detect threats or changes through visual or auditory observation. The percentage of vigilance behaviour at Semarang Zoo was 10.7% for binturong A, 11.0% for binturong B, and 0.5% for binturong C. This behaviour was a natural part of their daily lives. In captivity, binturongs were engaged in frequent movement, changing from one location to another without resting on trees or climbing up and down [15].

Defecation behaviour in binturongs, similar to urination, occurs during specific times of the day. While urination typically happens during the daytime, defecation or faecal elimination is more commonly observed at night. Binturongs select specific locations for

urination or defecation, often returning to the same spots. Besides serving a physiological need, defecation also functions to mark territory. By leaving faeces in designated areas, binturongs signal their presence to other binturongs and clarify territorial boundaries. The frequency of defecation behaviour varies among individuals, with Binturong B exhibiting a 0.5% occurrence of urination. In comparison, binturongs A and C show only 0.1% and 0.0%, respectively, indicating it is rarely observed in the latter two. According to [7], urination involves the expulsion of urine from the body, typically achieved by squatting and releasing urine onto the ground. During urination, the male's legs are intermittently contracted, and a few strides are taken ahead as urination nears completion. In the squat position, the tail touches the ground, absorbing urine that likely travels to tree limbs during climbing. Additionally, urine contacts the metatarsal area, as metatarsus scuffing occurs before, during, and after voiding. This scuffing subsequently transports urine to various locations. Disruptions to the animals, such as capturing the female for injections or relocating both individuals to the outdoor area, frequently result in increased scuffing.

## 4 Discussion

Designing an enclosure for binturongs involves replicating their natural arboreal and aquatic habitats while providing enrichment and stimulation to promote their overall lives [13]. Some important aspects to consider include arboreal structure and climbing opportunities, ground mobility and aquatic features, environmental enrichment and stimulation, nocturnal activity and daytime resting, visitor education, and environmental considerations.

Although binturongs may appear to have a leisure pace, they can be highly energetic. In addition to climbing, binturongs have demonstrated the ability to swim and even submerge themselves to obtain food. Furthermore, they utilize their environment to navigate between potential climbing spots and employ their prehensile tails as an extra limb for this activity. Zoo management suggested creating a stimulating and ever-changing setting for binturongs to investigate and ensure that there is enough vertical area available for climbing. Utilize enrichment techniques to diversify the environment, such as introducing various scents, using hollowed hanging bamboo to conceal food, and periodically altering the placement of hanging branches and hammocks [13]. The high utilization of den areas as a choice for binturongs to spend time and provide an option to be out of view from visitors, especially during the daytime, is observed at Chester Zoo [5].

Additional equipment related to the enclosure that requires attention includes information boards and warning signs. Concise information about the species, including their name, distribution, diet, behaviour, and conservation status, was provided by the information boards. Visitors are certain to benefit greatly and are provided with knowledge from these information boards. Warning signs should be visible in areas where guests may encounter animals to inform them about possible risks. Guests may face the risk injury from animals with horns, as well as the potential for being bitten or poked. In addition, the existence of electric fences or areas with potentially dangerous edges should be noted by warning signs [12].

Binturongs consume a substantial amount of fruit. However, their feeding habits are opportunistic, encompassing a wide range of food sources, including carrion, eggs, plant shoots, and leaves [1]. Their adept hunting skills further broaden their diet, allowing them to prey on small invertebrates, fish, birds, and small mammals whenever possible. In their natural habitat, which is primarily characterized by the consumption of *Ficus* fruits [19], binturongs also consume a diverse array of dietary items such as insects, birds, fish, rats, eggs, carcasses, frogs, and leaf buds. This varied diet not only meets their nutritional needs but also plays an important role in seed dispersal and small animal predation [20]. While in confinement, the manager recommended ensuring diverse food with sufficient options.

Diverse selection of fruits and vegetables can be provided as part of a meat-based carnivore diet enriched with additional nutrients. Food can be dispersed throughout the enclosure to promote digging and foraging behaviours [13].

Resting behaviour is crucial for physical recovery, whether it involves just relaxing the musculoskeletal system or also benefiting the central neurological system [21]. Each animal exhibited a different body posture while resting, which was also demonstrated by the binturong. When resting, the binturong is observed in a sleeping position on boards or wood with its eyes closed. In contrast, resting awake behaviour is shown with a resting posture but with eyes still open (Figure 9).



**Fig. 9.** Various resting behaviour postures in binturongs.

Binturongs were engaged in various activities in trees, being arboreal animals. Several aspects were involved in some moving behaviours of binturongs, such as having strong legs and claws to grip branches securely. Agile movement in trees, climbing, or even leaping between branches could be accomplished by them. Although binturongs were habitually found in trees, they could also walk on the ground. Their broad paws tended to be used to balance their bodies when walking on the ground. Exploring the environment to find food sources, seeking mates, or finding hiding spots were some reasons for moving behaviour.

In this study, only daytime observations were conducted, and nocturnal observations have yet to be performed. However, nocturnal data from other researchers are intriguing and may complement the findings from our previous research. Reproductive performance is regarded as a critical measure of success for conservation institutions. At the Semarang Zoo, breeding initiatives, particularly for binturongs, were not prioritized. Attention must be given to the 3:1 sex ratio, favouring a higher proportion of males to females, during the sexually mature phase. In addition to the composition of the sex ratio, significant importance was placed on the assessment of enclosures concerning animal welfare. Emphasis was given to factors such as the inclusion of enrichment activities, the design of enclosures to closely mimic natural habitats, and the provision of a varied diet.

## 5 Conclusion

The captive management of binturongs at Semarang Zoo could be improved to enhance their well-being. Enhancing enclosure conditions and providing a varied diet as recommended by nutrition experts could better support their natural behaviors and nutritional needs. Genetic diversity data will be critical for the long-term conservation of species. Due to various factors, the geographical origin of animals in captivity is often indeterminate. Zoo animals are typically maintained without clear geographic lineage, often as the offspring of multiple generations bred in captivity, with no documented knowledge of their original geographic ancestry. Phylogeographic studies are deemed essential to evaluate the genetic diversity of captive binturongs and ascertain their geographical origin.

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