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The Model of Proboscis Monkey Welfare in Taman Safari Indonesia Using Five Domain Animal Welfare

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ABSTRACT

The proboscis monkey (*Nasalis larvatus*), an endangered species endemic to Borneo, faces conservation challenges in the wild. Zoos play a crucial role in ex-situ conservation by ensuring species preservation and animal welfare. This study assesses the welfare of proboscis monkeys at Taman Safari Indonesia (TSI) Bogor using the Five Domain method from October 2022 to March 2023. The proboscis monkeys at TSI have a variety of behaviors similar to those observed in the wild. It shows positive welfare indicators, including social interactions, play, foraging, and grooming, with no abnormal behavior. Natural behavior and high use of environmental enrichment can be indicators of good welfare. This shows that efforts to provide suitable environments and care have promoted natural behaviors and preserved their welfare. The proboscis monkey welfare model can support ex-situ link synergy as a sustainable conservation strategy. The condition of proboscis monkeys at TSI is in the welfare category based on behavioral observations and comprehensive studies.

Introduction

Proboscis monkeys (*Nasalis larvatus*) are a protected primate species classified as Endangered on the IUCN Red List [1] and listed in Appendix I of CITES. Over the past 36 to 40 years, their population has declined by 50 to 80%. These monkeys play a crucial ecological role in wetland and mangrove ecosystems, contributing to forest silviculture regulation [2]. Without immediate conservation interventions, they face a high risk of local extinction within the next decade [3]. Ex-situ conservation programs, particularly through captive breeding in zoological institutions, play an important role in species preservation by supporting education, recreation, and scientific research [4]. The Southeast Asia Zoo Association (SEAZA) and *Perhimpunan Kebun Binatang Se-Indonesia* (PKBSI) have identified proboscis monkeys as a high priority for both in-situ and ex-situ conservation initiatives [5]. Taman Safari Indonesia (TSI) is one such institution engaged in breeding and maintaining this species.

Despite these initiatives, proboscis monkey breeding has faced significant challenges since 1975, with several failures reported in both Indonesian and international zoos. Biological and husbandry-related constraints, including limited understanding of species-specific behaviors, ineffective captive management strategies, nutritional imbalances, and chronic stress responses, have negatively impacted reproductive success [6]. Addressing these limitations is essential for enhancing breeding outcomes and ensuring sustainable ex-situ conservation programs. The systematic assessment of animal welfare serves as a comprehensive and evidence-based approach to improving captive management.

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This study evaluates the welfare of proboscis monkeys at TSI using the Five Domains Model of animal welfare, which assesses nutrition, environment, health, behavioral interactions, and mental state. This model, recognized and implemented by the World Association of Zoos and Aquariums (WAZA), SEAZA, and Wild Welfare, provides a structured approach to assessing and improving welfare conditions [7–9]. Five Domains Model has been applied to various species worldwide [7], research specifically assessing proboscis monkey welfare using this model remains limited, particularly in Indonesia. Studies on primate welfare have primarily focused on great apes and other commonly housed species [10], leaving gaps in the assessment and management of proboscis monkey welfare. Furthermore, it is unclear whether similar welfare assessments have been conducted in other countries, as most research has centered on more extensively studied primates in captivity [11]. This study aims to fill that gap by applying the Five Domains Model to assess the welfare of proboscis monkeys at TSI Cisarua, Bogor. The findings will contribute to scientific knowledge and inform best practices for ex-situ conservation strategies both nationally and internationally.

Materials and Methods

Study Area

The research was conducted for seven months, from October 2022 to April 2023. The research was conducted in Taman Safari Indonesia (TSI), Bogor. The geographical layout of TSI and the specific location of the proboscis monkey enclosure are illustrated in Figure 1. The total area is 138.5 hectares, situated in the buffer zone of Mount Gede Pangrango National Park, with altitudes ranging from 900 to 1,800 m above sea level and an average temperature of 16 to 27 °C. TSI represents one of the most established ex-situ conservation institutions in Southeast Asia, housing various endemic and endangered species, including the proboscis monkey (*Nasalis larvatus*). The controlled yet semi-natural environment provided by Taman Safari offers a unique opportunity to evaluate species-specific welfare indicators under human-managed conditions.

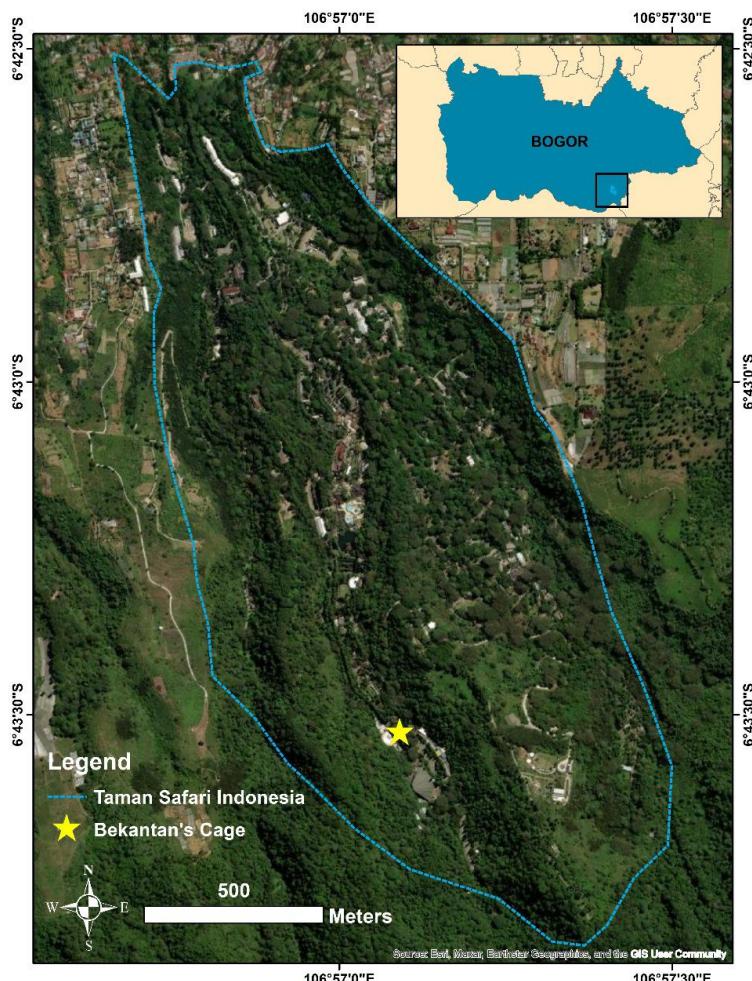


Figure 1. Map of Taman Safari Indonesia in Cisarua, Bogor, West Java.

Data Collection

Daily Behavior

Behavioral observations used the focal animal sampling method by recording the behavior of each proboscis monkey in turn for 10 minutes each [12]. Observations were conducted in the morning at 08.00–10.00 and in the afternoon at 15.00–17.00, paying attention to ingestive behavior, moving/locomotion, resting, grooming, agonistic, sexual, and other behaviors. Observations were made on five individual proboscis monkeys divided into age groups of adult males, adult females, juveniles, and infants (Table 1).

Table 1. Individual of Proboscis Monkey at TSI.

No	Name	Sex	Age group
1	Jasin	Male	Adult (9 years)
2	Mira	Female	Adult (9 years)
3	Loli	Female	Juvenile (3 years)
4	Ubay	Male	Juvenile (3 years)
5	Amar	Male	Infant (1 years)

Nutrition

Nutritional data were collected by knowing the type, feed preference, and weight of feed consumed by the proboscis monkeys at the TSI. The types of plants and parts consumed by proboscis monkeys were observed using the IARF (individual activity records of feeding) method [13]. Feed consumption weight was determined by collecting feed samples from the proboscis monkey group every morning for seven days and calculating the amount of feed consumed by the proboscis monkey group in one day. Feed consumption is obtained by reducing the weight given by the weight of the remaining feed (modification of Alikodra [14]). The total preference for the type of feed and daily feed weight were calculated as a percentage [15,16].

Environment

Environmental data were collected through temperature and humidity, and environmental conditions that might influence proboscis monkeys' conditions were evaluated. Temperature and humidity measurements at TSI using a thermohygrometer were measured in the morning and afternoon on 08.00 to 10.00 and 14.00 to 16.00. The main categories of environmental enrichment are divided into five categories: social, physical, occupational, sensory, and feed. Environmental enrichment data included the number and type of environmental enrichment in the cage [17].

Health

The proboscis monkey health data were obtained from visual observations and health history. Researchers carried out visual observations for one month by paying attention to the injuries and illnesses suffered by proboscis monkeys. Health history data included disease history, body weight, and the medical check-up schedule provided by the zoo management staff during the interview. The obtained health data were then analyzed in a literature study.

Behavioral Interaction

Observed behavioral interactions include proboscis monkey interactions with other individuals, species, and humans. Interactions between individuals include social and non-social interactions. Social behaviors include mating (sexual), cooperation (grooming and playing), and competition/agonism. Non-social behaviors include ingestive behavior, resting, and locomotion. Furthermore, the percentage of social and non-social behaviors is calculated to understand the social dynamics within proboscis monkey groups and provide insights into their well-being and adaptation in specific environments.

Data Analysis

Descriptive analysis describes and explains the data obtained from observations, literature studies, and observations. The data analyzed descriptively included nutritional, environmental, health, and behavioral interaction data. The mental status of the proboscis monkeys was determined by observing responses from negative/positive behavior to treatment during observation. A descriptive analysis was conducted to describe the data, analyze the welfare conditions of the proboscis monkeys, and create a proboscis monkey welfare model [7]. The data interpretation results will be presented in figures and tables.

Results

Daily Behavior

The percentage of the total daily behavior of proboscis monkeys at the TSI Bogor for age structure and each behavior is presented in Figure 2. Ingestive behavior in proboscis monkeys includes taking, holding, plucking, carrying, putting food into the mouth, and chewing it [3]. Proboscis monkeys at TSI had the highest percentage of ingestive behavior among adult male individuals (35.85%). The high percentage difference in age structure in the TSI can be caused by factors such as food availability and social hierarchy. Dominant individuals consume more food than other individuals do. Proboscis monkeys at TSI had the highest percentage of locomotion behavior observed in infants (55.73%). The highest percentage of resting behavior in proboscis monkeys at the TSI was observed in adult male individuals (27.04%). This follows Bismark et al. [18] statement, which states that adult male sleep and rest more. The highest percentage of grooming behavior in the TSI group occurred in adult females (49.31%) and juveniles (49.01%).

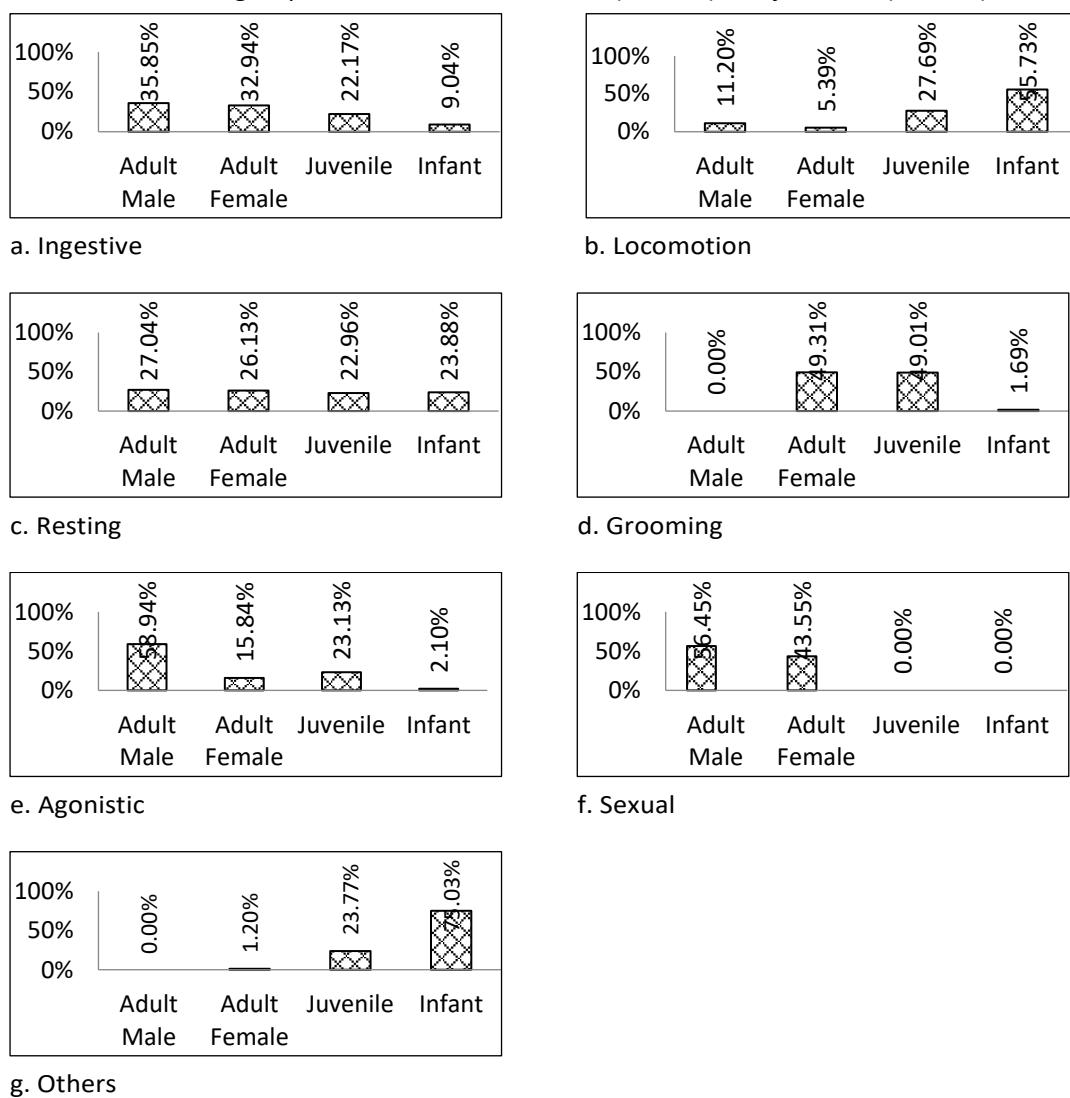


Figure 2. Percentage of the total daily behavior of proboscis monkeys at TSI Bogor for age structure and each behavior: (a) ingestive, (b) locomotion, (c) resting, (d) grooming, (e) agonistic, (f) sexual, and (g) others.

Females generally groom males before and after copulation [19]. Female juveniles in the TSI were observed approaching and making sounds when asking for grooming from adult females. The percentage of agonistic behavior in proboscis monkeys in the TSI was the highest in adult males (58.94%). Other events, such as self-protection against predators, have been observed in adult males on Curiak Island. Adult males who feel threatened will open their mouths with a "honk" sound and assume a body position ready to attack [20].

Sexual behavior in TSI was observed in the adult male and female age groups at 56.45% and 43.55%, respectively. Proboscis monkeys in TSI initiate sexual behavior by pursing their lips, shaking their heads, and turning to expose the backs of their bodies [21]. When adult males and females' mate, juveniles and infants show approaching and disturbing behavior by climbing on adult females and touching adult males [22].

Another behavior observed was the highest playing behavior among infants (75.03%). This is because playing provides short-term benefits for their development. As animals age, their playing behavior decreases because benefits and motivation decrease [23,24]. Low playing behavior can be influenced by several factors, such as adequacy of food, age structure, and weather [25]. A comparison of behavior between proboscis monkeys in captivity and those in the wild can provide valuable insights into the influence of the environment on their welfare. The percentage of total daily behaviors of proboscis monkeys on TSI Bogor and Curiak Island for each behavior is shown in Figure 3.

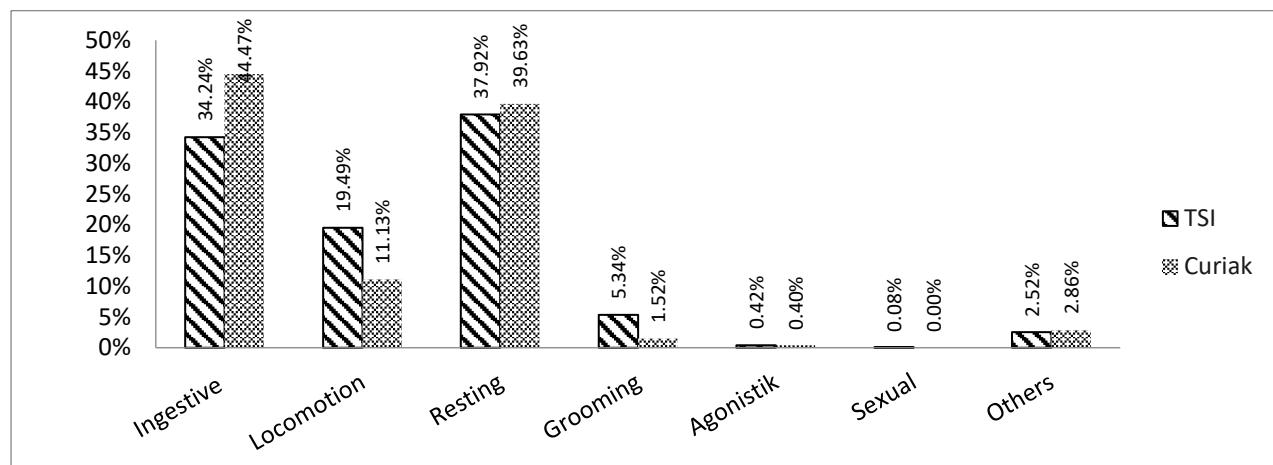


Figure 3. The percentage of total daily behaviors of proboscis monkeys in TSI Bogor and Curiak Island for each behavior.

The proboscis monkeys in the TSI Bogor allocated a higher proportion of their time to resting, comprising 39.63% of their activities. This shows the adaptation of proboscis monkeys to energy efficiency. Leaf-eating animals, such as proboscis monkeys, require extended periods to digest food into energy. In contrast, on Curiak Island, ingestive behavior represented the highest percentage of activities, at 44.47%, among proboscis monkeys, whereas in TSI, the percentage of ingestive behavior was lower (34.24%). This distinction arises from the greater diversity and availability of food sources in the natural environment of Curiak Island, which enables proboscis monkeys to select and exploit food sources. Proboscis monkeys living in their natural habitat can choose foods with the necessary nutrients, such as protein and fiber, through leaf color selection (visual) and taste [26,27]. A variety of behaviors exhibited by proboscis monkeys has been observed in both captive and wild animals. This shows that efforts to provide suitable environments and care for captive animals have succeeded in promoting natural behaviors and preserving their welfare.

Discussion

Nutrition

Fifteen types of feed at the TSI are 15 types of feed. Mustard greens were the highest type of feed consumed by proboscis monkeys. Feeding of proboscis monkeys in the TSI exhibition cage on 09.00–10.00 and 14.00–15.00. Consumption of proboscis monkey feed in the afternoon is given at 16.00–17.00 in the sleeping cage. Proboscis monkeys consume leaves and almost all plant parts, including roots, bark, leaves, fruit, and flowers [24]. The proportion of the proboscis monkey's diet is dominated by leaf type, including mustard greens, kemang, orchid tree leaves, spinach, white lead tree, and bunut. The proboscis monkeys at TSI consume vegetables and fruits, but proboscis monkeys were observed leaving most of the plant parts in the form of stems, roots, and leaves. This behavior of proboscis monkeys aims to obtain better nutrition, make energy efficient in digesting feed, and avoid the effects of toxins [20]. The proportion of feed menu items for the proboscis monkey group had an average wet weight of 7,389 g/day or 7.4 kg/day. The average daily consumption of proboscis monkeys was 68.99%, with an average wet weight of 5,072 g/day or 5 kg/day.

Each proboscis monkey consumes 1,000 g/day per individual. In Bismark and Hidayat et al. [20,28], it was estimated that in mangrove forests, proboscis monkeys consume food per day ranging from 1,500 to 1,750 g (fresh weight/FW) of leaves, while Pangestu et al. [29] estimated 900 g (FW) and Soendjoto et al. [30] the amount of feed per day ranged from 919.96 to 1,537.59 g wet weight. This shows that the daily consumption of proboscis monkey feed at the TSI is sufficient. However, individual feed calculations must be carried out considering the level of consumption, and the needs of each individual are undoubtedly different. Age structure is thought to be a factor that influences this, so further research is needed to accurately determine the feed weight requirements of proboscis monkeys.

It is essential to concern to the food menu in the zoo by assessing the nutritional content, such as Ca and P, and the enrichment of food around the enclosure. In colobine primates, it is recommended to increase the number of leaves in their diet [31,32]. The leaves consumed by proboscis monkeys in the wild contain high levels of protein, phosphorus, and potassium and are low in fiber [26]. Proboscis monkeys prefer food sources with high tannin levels [30]. This was also found in the food menu at TSI, namely the orchid tree (*Bauhinia purpurea*) [33] and wild sea rambai (*Sonneratia caseolaris*) [3,34,35]. This indicates a high tolerance for feed tannin levels. The digestive mechanism of proboscis monkeys can neutralize the effect of tannins through the bacteria contained in the digestion of proboscis monkeys, so that proboscis monkeys have a high tolerance for tannin content [36]. Observing ingestive behavior in proboscis monkeys is helpful for understanding their response/output (mental) of proboscis monkeys to the input factors (nutrition) and processes that have been given. Proboscis monkeys at TSI consume feed with appetite, as indicated by the high percentage of proboscis monkeys' ingestive behavior (34.24%) (Figure 1).

Environment

Based on temperature and humidity measurement activities, TSI has a temperature between 19–22 °C with an average daily temperature of 21.1 °C. The TSI air humidity ranges from 83 to 99%, with an average daily humidity of 96%. The temperature and humidity in the TSI were not significantly different. When observing the weather conditions at the TSI during October and November 2023, the rain intensity was high. Temperatures in the natural habitat of proboscis monkeys range from 23 to 32 °C throughout the year [19].

From the perspective of captive primate behavioral research, a zoo environment is primarily characterized by chronic human presence, spatial restriction, and intensive management [37]. TSI provides three types of enclosures for proboscis monkeys, namely exhibition cages, sleeping cages, and clamp cages. It is designed as a naturalistic exhibit, with environmental enrichment features that closely replicate the species' natural mangrove habitat. The sleeping and clamp cages serve as support enclosures for rest, isolation, or veterinary care, depending on the needs of the individual animals. Naturalistic design positively influences visitors because it provides insight into how proboscis monkey behaves in their wild environments and has a positive welfare effect on them [38,39].

According to Bloomsmith et al. [17], environmental enrichment in captive can be classified into five categories: social, physical, occupational, sensory, and nutritional. Environmental enrichment at TSI is presented in Table 2. Enriching the food environment in TSI Bogor includes providing water fountains, tree branches, and trunks. Fountains are used for drinking and playing behavior in proboscis monkeys, whereas tree trunks/branches are provided as environmental enrichment for food to support natural feeding behavior. In the wild, proboscis monkeys consume tree bark by biting and peeling it off. A similar observation was made in proboscis monkeys at TSI Bogor, which shows the optimal use of environmental enrichment feed. Sexual behavior had the lowest percentage at 0.08% in the TSI. The observed low sexual behavior may be caused by the fact that Mira is the only adult female in this group who is still lactating her baby. Social enrichment is needed to provide opportunities for proboscis monkeys to promote social interactions, such as grooming, playing, and maintaining close proximity, which are essential social behaviors in primates that serve to strengthen social bonds and reduce stress. Promoting these behaviors in captivity contributes positively to animal welfare and psychological well-being [10,40]. Play behavior supports the development of muscular strength, social competencies, motor skills, and adaptive responses to potential predators [41–43].

Table 2. Environmental enrichment at Taman Safari Indonesia.

No	Environmental enrichment's categories				
	Physical	Social	Occupational	Sensory	Feed
1	Ropes	-	Grass		Tree trunk/ branches
2	Tire		Stem tree		Pool

Sleeping trees are a critical component influencing the habitat preferences of proboscis monkeys. They prefer tall trees along riverbanks to minimize predation and mosquito disturbance while enabling social communication with other individuals [20,22,44–46]. The choice of a sleeping tree is thought to influence several aspects, including distance from the riverbank, tree height, tree diameter, branches, and canopy connectivity [46]. This aspect can be used as a reference for zoos to design environmental enrichment in the form of sleeping proboscis monkey trees. This has been implemented in the proboscis monkey captivity, where they were seen sitting together between different age groups, and adult males were seen sitting while watching their surroundings.

Environmental enrichment refers to the structures and stimuli that promote species-specific behavior that is important and beneficial from the perspective of an individual [45]. A lack of environmental enrichment that supports natural animal behavior can give rise to abnormal or stereotyped behavior. Based on the results, the proboscis monkeys at the TSI showed no abnormal behavior. Natural behavior and high use of environmental enrichment can be indicators of good well-being. Proboscis monkeys at TSI showed a locomotion percentage of 19.49%, which shows that environmental enrichment is optimally used. Locomotion behavior is beneficial for physical development, such as developing and strengthening bones and muscles, and increasing cardiopulmonary capacity [46,47]. In addition, enrichment that promotes aggressive behavior should be avoided because it can injure animals and negatively impact welfare.

Health

Bacteria, viruses, protozoa, fungi, and ectoparasites cause infectious diseases that are commonly encountered in primates. Several captive proboscis monkeys have been reported to experience health issues, including kidney failure [32], and parasitic infections such as *Trichiuris* sp. and *Ascaris* sp., as identified in fecal examinations [47]. Kidney failure occurs in proboscis monkeys in the Yokohama Zoological Gardens because of a diet with high Ca and low P levels. Apart from captivity, proboscis monkeys are also known to be attacked by the Trichurids parasite in the wild: *Strongylida*, *Strongyloides* sp., *Ascaris* sp., and *Oxyurida* [48]. Bacteria of the *Lactobacillus nasalidis* type were found in the stomachs of captive proboscis monkeys at the Japanese Zoo, and proboscis monkeys in Malaysian mangrove forests [49].

After observing for one month at TSI, the proboscis monkeys were visually assessed and found to be in good health. Indicators included excellent physical condition, no injuries or illnesses, active interaction with the environment, normal behavior, and no stereotyped behavior. Their sensory functions appeared intact, as evidenced by appropriate responses to environmental stimuli. Daily health monitoring was conducted by assessing physical appearance, appetite, feces, urine, and daily behavior. If there are any irregularities or abnormalities in the observation, the keeper reports it to the veterinarian or manager (headkeeper) for further observation. TSI implements routine medical check-ups (MCUs) for each proboscis monkey, conducted one to two times per year, to monitor and document health status over time. The MCU protocol includes a comprehensive health assessment, consisting of hematological and biochemical blood tests, body weight measurements, deworming, serological testing for hepatitis A and B, tuberculosis screening using the tuberculin skin test, radiographic (X-ray) evaluations, oropharyngeal swabs, and herpes B virus screening. Based on interviews with veterinary staff and recent MCU results, all individual proboscis monkeys at TSI were reported to be in good health.

Behavioral Interaction

Proboscis monkeys have a one-male multi-female group (OMG) social structure [50–52]. At TSI behavioral observations were conducted to assess both social and non-social interactions among individuals in the group. The total proportion of time spent engaging in social behaviors was 8.35%. This percentage aligns with findings from studies on other colobine primates, which also demonstrate relatively low frequencies of social interactions compared to other primate taxa (e.g., African colobines: 3–15%; Asian colobine 0.1–6.5%) [53]. According to Sha et al. [54], compatible social groups exhibit positive interactions, including sexual behavior, alloparenting, play, and mutual protection from threats. These positive interactions were also observed in the proboscis monkeys at TSI, indicating a stable and compatible social structure. Effective breeding management at TSI is evidenced by an increase in reproductive success.

Maintaining appropriate group composition and regulating reproduction are essential components in supporting the overall welfare of captive primates [55–57]. However, negative interactions such as social conflict may trigger aggressive or fearful behaviors, increase the risk of injury, and ultimately compromise animal welfare. Agonistic behaviors observed among individuals are often linked to the establishment of social hierarchies, with adult females frequently displaying protective behaviors toward their infant [58].

Observations at TSI recorded the presence of other species within the proboscis monkey (*Nasalis larvatus*) enclosure, including squirrels, insects, and snakes. The frequent presence of squirrels and insects, particularly those accessing food sources, may lead to interspecific competition and trigger either agonistic or tolerant responses from the proboscis monkey. Habitat overlap with these species could contribute to stress and disrupt feeding behavior.

Thus, routine monitoring and enclosure management are essential to minimize competitive interactions and support animal welfare. Interactions between proboscis monkey and humans at TSI include tourism activities, animal care, and animal management (including research). Animal management in zoos also requires human resources who have sufficient education, are skilled, communicative, and have integrity [14]. Keepers are zoo managers who most often interact with animals. The interaction between proboscis monkeys and keepers at TSI includes feeding, cage cleanliness management, and healthcare. Keepers must observe and understand the signs of good health and welfare in animals. In some zoos, keepers play a role in assessing the level of welfare experienced by the animals they handle.

However, this assessment is subjective and may influence the observers' attitudes and perceptions of animal welfare [59]. Veterinarians also interact directly with animals through routine observation and health management procedures. Proboscis monkeys should be trained to accept medical interventions it can minimize stress and discomfort. This is particularly important as proboscis monkeys are highly sensitive to human presence. Visitor behaviors such as speaking loudly or tapping on the glass of enclosures can provoke aggression and elevate stress levels in these animals. To mitigate such disturbances, preventive strategies should include educating visitors about appropriate behavior in zoos and ecotourism settings. Providing accessible and engaging information on animal biology and ecology can enhance the educational value of the zoo and strengthen its conservation outreach.

Mental State

Good mental health is linked to an animal's biological and physical needs (nutrition, environment, health, and behavioral interactions). They can be achieved when all these needs are met. A comparison of behavior based on age structure in proboscis monkeys in captivity and natural habitats was performed to assess the welfare of proboscis monkeys [60,61]. Overall, proboscis monkeys in the TSI showed similar variations in behavior and response to the environment. However, it should be noted that each proboscis monkey is treated as the same in captivity and does not guarantee the same response in each individual. Each proboscis monkey may react differently depending on individual characteristics and condition. Therefore, welfare assessments should be conducted individually to ensure appropriate responses to management interventions. Figure 4 outlines key indicators for evaluating the welfare of proboscis monkeys, highlighting both potential positive and negative behavioral responses.

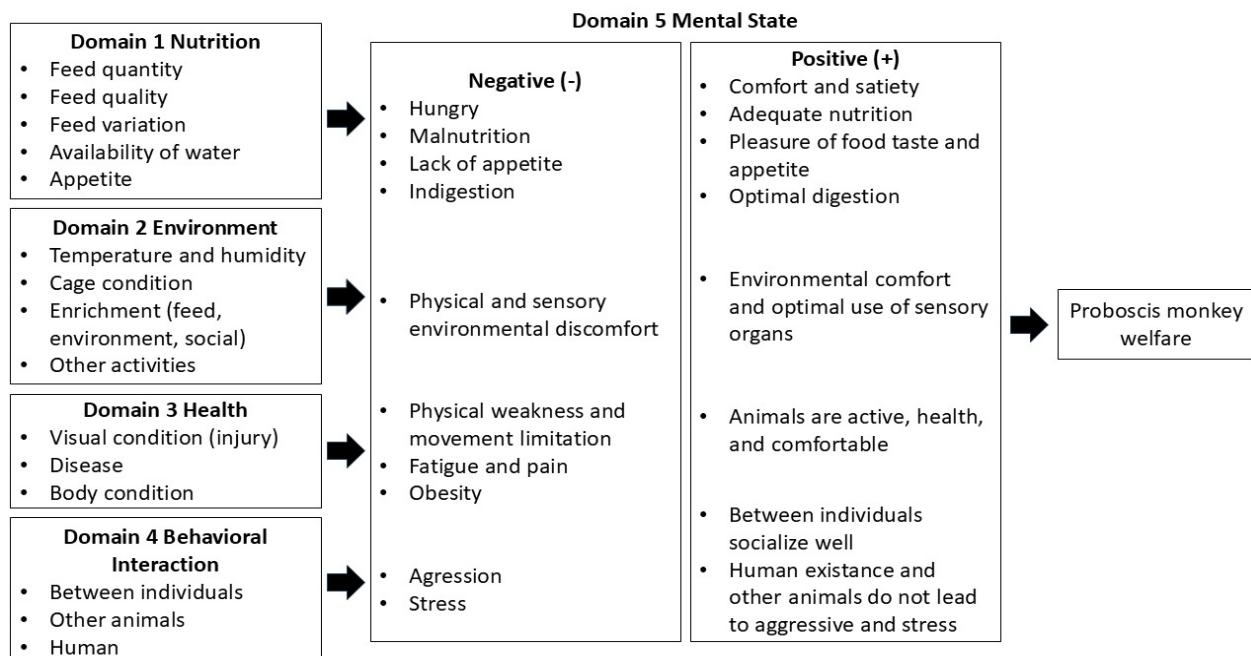


Figure 4. Aspects of animal welfare assessment. Source: modification of Mellor et al. [7].

This assessment can be used as a reference for selecting appropriate treatments, whether positive or negative, for zoo or captive proboscis monkeys. The influence of treatment on aspects that have a negative impact can be removed, maintained, modified, or given other treatments based on consideration [7]. Conversely, treatments associated with positive behavioral indicators should be preserved, enhanced, and assessed regularly to support or improve the animals' positive welfare.

The Model of Proboscis Monkey Welfare

The proboscis monkey welfare model is illustrated in Figure 5. This model is recommended for application, consideration, and evaluation by animal welfare practitioners, particularly in the context of ex-situ conservation of proboscis monkeys. The input component includes four key domains essential to the welfare of proboscis monkeys. In captive settings, proboscis monkeys rely on human resources to fulfill their physiological and behavioral needs, which are addressed in the process component of the model. The output component focuses on the assessment of mental status Domain 5 reflecting a state in which proboscis monkeys are physically healthy and exhibit normal behavior. These output indicators can serve as valuable references for TSI in the ongoing maintenance, development, and evaluation of breeding management strategies aimed at promoting and sustaining positive welfare outcomes.

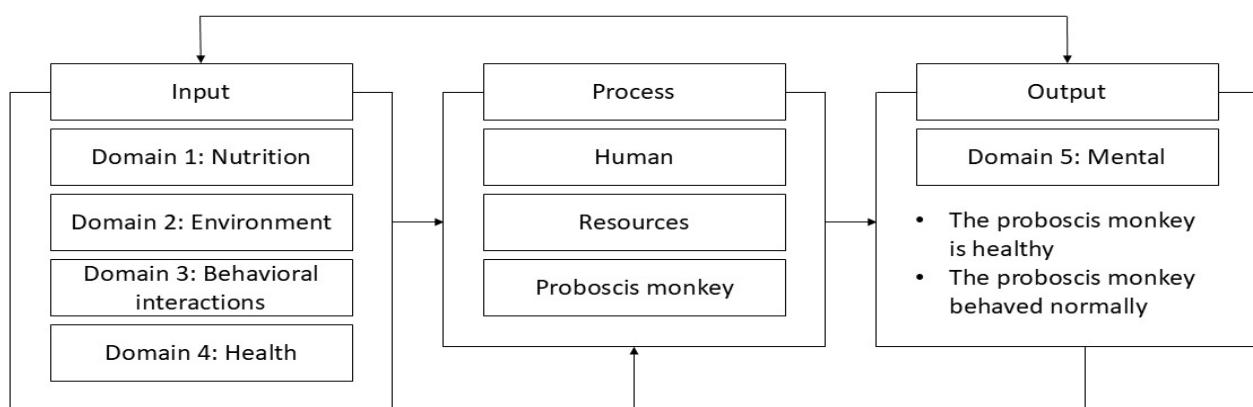


Figure 5. Proboscis monkey welfare model at TSI (Modification Mellor et al. [7], Alikodra [14]).

The aspects contained in this model are prepared based on comparative responses to the behavior of proboscis monkeys in the wild and captivity through literature studies. Aspects of this model can be developed at any time along with developments in science related to animal welfare, especially proboscis monkeys. Apart from behavior, other aspects that determine mental status or physiological stress responses can be measured by heart rate, blood pressure, or immune function [62].

Conclusion

The proboscis monkey welfare model can support ex-situ link synergy as a sustainable conservation strategy. Five domains of animal welfare can be used as an indicator of animal welfare, especially proboscis monkeys, by focusing on aspects of input (nutrition, environment, health, and behavioral interactions), process (human resource management, natural resources, and proboscis monkeys), and output (mental status). This model is a novelty that can be useful for science to further develop and research the science of primate welfare. Its implementation can enhance welfare monitoring and management practices in zoological institutions, particularly at Taman Safari Indonesia, and serve as a reference for national conservation bodies such as the Ministry of Environment and Forestry. Based on this research, the condition of proboscis monkeys at TSI is in the prosperous category based on behavioral observations and comprehensive studies.

Author Contributions

CDI: Conceptualization, Methodology, Data Analysis, Writing – review & editing; **HSA:** Methodology, Writing – review & editing, Supervision; **JM:** Writing – review & editing; **YT:** Writing – review & editing; **HSD:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Conflicts of Interest

There are no conflicts to declare.

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References

1. Boonratana, R.; Cheyne, S.M.; Traeholt, C.; Nijman, V.; Supriatna, J. *Nasalis larvatus*. *The IUCN Red List of Threatened Species* 2020: e.T14352A17945165.
2. Desnindriani, P. Penelusuran Terancam Punahnya Satwa Bekantan Di Kalimatan Selatan Dalam Penyutradaraan Film Dokumenter Investigasi “*Nasalis larvatus*”. Undergraduate thesis, Institut Seni Yogyakarta, Bantul, ID, 2020.
3. Alikodra, H.S. *Bekantan Perjuangan Melawan Kepunahan*; Penerbit Fakultas Kehutanan IPB: Bogor, ID, 2015;
4. Bismark, M. *Biologi Konservasi Bekantan (Nasalis larvatus)*; Pusat Penelitian dan Pengembangan Hutan dan Konservasi Alam: Bogor, Indonesia, 2009; ISBN 978-979-314-542-6.
5. Manansang, J.; Traylor-Holzer, K.; Reed, D.; Leus, K. *Indonesian Proboscis Monkey Population and Habitat Viability Assessment: Final Report*; IUCN/SSC, Conservation Breeding Specialist Group: Apple Valley, USA, 2005;
6. Agoramoorthy, G.; Alagappasamy, C.; Hsu, M.J. Can Proboscis Monkeys Be Successfully Maintained in Captivity? A Case of Swings and Roundabouts. *Zoo Biol.* **2004**, *23*, 533–544, doi:10.1002/zoo.20018.
7. Mellor, D.J.; Beausoleil, N.J.; Littlewood, K.E.; McLean, A.N.; McGreevy, P.D.; Jones, B.; Wilkins, C. The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare. *Animals* **2020**, *10*, 1–14, doi:10.3390/ani10101870.
8. Mellor, D.J.; Beausoleil, N.J. Extending the “Five Domains” Model for Animal Welfare Assessment to Incorporate Positive Welfare States. *Animal Welfare* **2015**, *24*, 241–253.
9. Mellor, D. Operational Details of the Five Domains Model and Its Key Applications to the Assessment and Management of Animal Welfare. *Animals* **2017**, *7*, 1–20, doi:10.3390/ani7080060.
10. Sherwen, S.L.; Hemsworth, P.H. The Visitor Effect on Zoo Animals: Implications and Opportunities for Zoo Animal Welfare. *Animals* **2019**, *9*, 1–27, doi:10.3390/ani9060366.
11. Maple, T.L.; Perdue, B.M. *Zoo Animal Welfare*; Springer: Berlin, Germany, 2013; Volume 14.
12. Altmann, J. Observational Study of Behavior: Sampling Methods. *Behaviour* **1974**, *49*, 227–266, doi:10.1163/156853974X00534.
13. Yeager, C.P. Feeding Ecology of the Proboscis Monkey (*Nasalis larvatus*). *Int. J. Primatol.* **1989**, *10*, 497–530, doi:10.1007/BF02739363.
14. Alikodra, H.S. *Teknik Pengelolaan Satwa Liar*; IPB Press: Bogor, ID, 2010; ISBN 978-979-493-192-9.
15. Odum, E.P. *Fundamentals of Ecology*, 3rd ed.; W.B. Saunders Co: Philadelphia, USA, 1971.
16. Suherli, D.; Harianto, S.P.; Widodo, Y. Study of Behavior and Drop in Food of Sulawesi Black Monkey (*Macaca Nigra*) in Agro Animal and Garden Tours Bumi Kedaton. *Jurnal Sylva Lestari* **2016**, *4*, 1–8.
17. Bloomsmith, M.A.; Brent, L.Y.; Schapiro, S.J. Guidelines for Developing and Managing an Environmental Enrichment Program for Nonhuman Primates. *Lab. Anim. Sci.* **1991**, *41*, 372–377.
18. Bismark, M. Perilaku Bekantan (*Nasalis larvatus Wurmb*) Dalam Memanfaatkan Lingkungan Hutan Bakau Di Taman Nasional Kutai, Kalimantan Timur. Thesis, IPB University, Bogor, 1986.
19. Matsuda, I.; Murai, T.; Clauss, M.; Yamada, T.; Tuuga, A.; Bernard, H.; Higashi, S. Regurgitation and Remastication in the Foregut-Fermenting Proboscis Monkey (*Nasalis larvatus*). *Biol. Lett.* **2011**, *7*, 786–789, doi:10.1098/rsbl.2011.0197.

20. Bismark, M. Ekologi Makan Dan Perilaku Bekantan (*Nasalis larvatus* Wurmb) Di Hutan Bakau Taman Nasional Kutai, Kalimantan Timur. Dissertation, IPB University, Bogor, 1994.

21. Hollihn, U. Remarks on the Breeding and Maintenance of Colobus Monkeys Colobus Guereza, Proboscis Monkeys *Nasalis larvatus* and Douc Langurs *Pygathrix Nemaeus* in Zoos. *International Zoo Yearbook* **1973**, *13*, 185–188, doi:10.1111/j.1748-1090.1973.tb02146.x.

22. Bernard, H.; Abram, N.K.; Kulanthavelu, M.; Oram, F.; Matsuda, I. Population Trends and Conservation Status of Proboscis Monkeys (*Nasalis larvatus*) in the Face of Habitat Change in the Klias Peninsula, Sabah, Borneo, Malaysia. *Raffles Bulletin of Zoology* **2021**, *69*, 176–187, doi:10.26107/RBZ-2021-0015.

23. Caro, T.M. Sex Differences in the Termination of Social Play in Cats. *Anim. Behav.* **1981**, *29*, 271–279, doi:10.1016/S0003-3472(81)80174-1.

24. Chalmers, N.R.; Locke-Haydon, J. Temporal Patterns of Play Bouts in Captive Common Marmosets (*Callithrix jacchus*). *Anim. Behav.* **1981**, *29*, 1229–1238, doi:10.1016/S0003-3472(81)80074-7.

25. Boissy, A.; Manteuffel, G.; Jensen, M.B.; Moe, R.O.; Spruijt, B.; Keeling, L.J.; Winckler, C.; Forkman, B.; Dimitrov, I.; Langbein, J.; et al. Assessment of Positive Emotions in Animals to Improve Their Welfare. *Physiol. Behav.* **2007**, *92*, 375–397, doi:10.1016/j.physbeh.2007.02.003.

26. Yeager, C.P.; Silver, S.C.; Dierenfeld, E.S. Mineral and Phytochemical Influences on Foliage Selection by the Proboscis Monkey (*Nasalis larvatus*). *Am. J. Primatol.* **1997**, *41*, 117–128.

27. Matsuda, I.; Clauss, M.; Tuuga, A.; Sugau, J.; Hanya, G.; Yumoto, T.; Bernard, H.; Hummel, J. Factors Affecting Leaf Selection by Foregut-Fermenting Proboscis Monkeys: New Insight from in Vitro Digestibility and Toughness of Leaves. *Sci. Rep.* **2017**, *7*, 1–10, doi:10.1038/srep42774.

28. Hidayat, M.; Amintarti, S.; Rezeki, A. Pengembangan Booklet Jenis Tumbuhan Sumber Pakan Bekantan Di Kawasan Stasiun Riset Pulau Curiak. *JUPEIS: Jurnal Pendidikan dan Ilmu Sosial* **2023**, *2*, 85–91, doi:10.57218/jupeis.Vol2.Iss1.537.

29. Pangestu, A.; Setiadi, Y.; Arifin, H.S. Flora Biodiversity at Proboscis Monkey Habitat in Ecotourism Area, Tapin District, South Kalimantan. *Jurnal Ilmu Pertanian Indonesia* **2019**, *24*, 359–365, doi:10.18343/jipi.24.4.359.

30. Soendjoto, M.A. Adaptasi Bekantan (*Nasalis larvatus* Wumb) Terhadap Hutan Karet: Studi Kasus Di Kabupaten Tabalong, Kalimantan Selatan). Dissertation, IPB University, Bogor, 2005.

31. Matsuda, I.; Bernard, H.; Tuuga, A.; Nathan, S.K.S.S.; Sha, J.C.M.; Osman, I.; Sipangkui, R.; Seino, S.; Asano, S.; Wong, A.; et al. Fecal Nutrients Suggest Diets of Higher Fiber Levels in Free-Ranging than in Captive Proboscis Monkeys (*Nasalis larvatus*). *Front. Vet. Sci.* **2018**, *4*, 1–5, doi:10.3389/fvets.2017.00246.

32. Hoshino, S.; Seino, S.; Azumano, A.; Tuuga, A.; Nathan, S.K.S.S.; Saldivar, D.A.R.; Goossens, B.; Salgado-Lynn, M.; Matsuda, I.; Yayota, M. Modifying the Diets of Captive Proboscis Monkeys in a Temperate Zoo to Reduce Weight Loss and Renal Disease. *Primates* **2023**, *64*, 123–141, doi:10.1007/s10329-022-01031-y.

33. Aryantini, D. Aktivitas antioksidan dan kandungan tanin total ekstrak etanol daun kupu-kupu (*Bauhinia purpurea* L.). *Jurnal Farmagazine* **2021**, *8*, 54–60, doi:10.47653/farm.v8i1.537.

34. Atmoko, T.; Ma'ruf, A.; Rinaldi, S.; Sitepu, B. Penyebaran Bekantan (*Nasalis larvatus* Wurmb.) Di Teluk Balikpapan, Kalimantan Timur. In Prosiding Seminar Hasil-Hasil Penelitian BPTKSDA Samboja, Balikpapan, Indonesia, 3 November 2011; pp. 71–83.

35. Zainudin; Rezeki, A. Feeding Activity and Diet of Proboscis Monkey (*Nasalis larvatus*) in Bakut Island, Barito Kuala Regency. In Prosiding Seminar Nasional Lahan Basah, Banjarmasin, Indonesia, 11 November 2017.

36. Besharati, M.; Maggiolino, A.; Palangi, V.; Kaya, A.; Jabbar, M.; Eseceli, H.; De Palo, P.; Lorenzo, J.M. Tannin in Ruminant Nutrition: Review. *Molecules* **2022**, *27*, 1–26, doi:10.3390/molecules27238273.

37. Hosey, G.R. How Does the Zoo Environment Affect the Behaviour of Captive Primates? *Appl. Anim. Behav. Sci.* **2005**, *90*, 107–129, doi:10.1016/j.applanim.2004.08.015.

38. Altman, J.D. Animal Activity and Visitor Learning at the Zoo. *Anthrozoos* **1998**, *11*, 12–21, doi:10.1080/08927936.1998.11425083.

39. Melfi, V.A.; McCormick, W.; Gibbs, A. A Preliminary Assessment of How Zoo Visitors Evaluate Animal Welfare According to Enclosure Style and the Expression of Behavior. *Anthrozoos* **2004**, *17*, 98–108, doi:10.2752/089279304786991792.

40. Husband, S.; Mayo, L.K.; Sodaro, C. *Environmental Enrichment for Captive Animals*; Young, R.J., Ed.; Wiley: Oxford, UK, 2003; ISBN 9780632064076.

41. Caro, T.M. Short-Term Costs and Correlates of Play in Cheetahs. *Anim. Behav.* **1995**, *49*, 333–345, doi:10.1006/anbe.1995.9999.

42. Nunes, S.; Muecke, E.-M.; Lancaster, L.T.; Miller, N.A.; Mueller, M.A.; Muelhaus, J.; Castro, L. Functions and Consequences of Play Behaviour in Juvenile Belding's Ground Squirrels. *Anim. Behav.* **2004**, *68*, 27–37, doi:10.1016/j.anbehav.2003.06.024.

43. Bekoff, M. Motor Training and Physical Fitness: Possible Short- and Long-term Influences on the Development of Individual Differences in Behavior. *Dev. Psychobiol.* **1988**, *21*, 601–612, doi:10.1002/dev.420210610.

44. Matsuda, I.; Tuuga, A.; Akiyama, Y.; Higashi, S. Selection of River Crossing Location and Sleeping Site by Proboscis Monkeys (*Nasalis larvatus*) in Sabah, Malaysia. *Am. J. Primatol.* **2008**, *70*, 1097–1101, doi:10.1002/ajp.20604.

45. Feilen, K.L.; Marshall, A.J. Sleeping Site Selection by Proboscis Monkeys (*Nasalis larvatus*) in West Kalimantan, Indonesia. *Am. J. Primatol.* **2014**, *76*, 1127–1139, doi:10.1002/ajp.22298.

46. Bernard, H.; Matsuda, I.; Hanya, G.; Ahmad, A.H. Characteristics of Night Sleeping Trees of Proboscis Monkeys (*Nasalis larvatus*) in Sabah, Malaysia. *Int. J. Primatol.* **2011**, *32*, 259–267, doi:10.1007/s10764-010-9465-8.

47. Ramadhani, M.; Nurhidayah, N.; Kurniawati, D.A.; Purwadi, M.; Rafiq, F.A.; Kusumaningtyas, E.; Endrawati, D.; Hidayatik, N.; Prastiya, R.A.; Mariya, S.S.; et al. Gastrointestinal Helminths of Captive Proboscis Monkey (*Nasalis larvatus*) in Surabaya Zoo, Indonesia. *J. Med. Primatol.* **2024**, *53*, e12719, doi:10.1111/jmp.12719.

48. Klaus, A.; Strube, C.; Röper, K.M.; Radespiel, U.; Schaarschmidt, F.; Nathan, S.; Goossens, B.; Zimmermann, E. Fecal Parasite Risk in the Endangered Proboscis Monkey Is Higher in an Anthropogenically Managed Forest Environment Compared to a Riparian Rain Forest in Sabah, Borneo. *PLoS One* **2018**, *13*, e0195584, doi:10.1371/journal.pone.0195584.

49. Hashido, S.N.; Tsuchida, S.; Azumano, A.; Goossens, B.; Saldivar, D.A.R.; Stark, D.J.; Tuuga, A.; Ushida, K.; Matsuda, I. Isolation of Bacteria from Freeze-Dried Samples and the Functional Characterization of Species-Specific Lactic Acid Bacteria with a Comparison of Wild and Captive Proboscis Monkeys. *Microorganisms* **2023**, *11*, 1–12, doi:10.3390/microorganisms11061458.

50. Bennett, E.L.; Sebastian, A.C. Social Organization and Ecology of Proboscis Monkeys (*Nasalis larvatus*) in Mixed Coastal Forest in Sarawak. *Int. J. Primatol.* **1988**, *9*, 233–255, doi:10.1007/BF02737402.

51. Boonratana, R. Social Organisation of Proboscis Monkeys (*Nasalis larvatus*) in the Lower Kinabatangan, Sabah, Malaysia. *Malaysian Nature Journal* **2002**, *56*, 57–75.

52. Yeager, C.P. Proboscis Monkey (*Nasalis larvatus*) Social Organization: Intergroup Patterns of Association. *Am. J. Primatol.* **1991**, *23*, 73–86, doi:10.1002/ajp.1350230202.

53. Kirkpatrick, C. Asian Colobines: Diversity Among Leaf-Eating Monkey. In *The International Encyclopedia of Primatology*; Wiley, New Jersey, USA, 2017; ISBN 978-111-917-931-3.

54. Sha, J.C.M.; Alagappasamy, S.; Chandran, S.; Cho, K.M.; Guha, B. Establishment of a Captive All-male Group of Proboscis Monkey (*Nasalis larvatus*) at the Singapore Zoo. *Zoo Biol.* **2013**, *32*, 281–290, doi:10.1002/zoo.21020.

55. Asa, C. Weighing the Options for Limiting Surplus Animals. *Zoo Biol.* **2016**, *35*, 183–186, doi:10.1002/zoo.21293.

56. Ferrie, G.M.; Becker, K.K.; Wheaton, C.J.; Fontenot, D.; Bettinger, T. Chemical and Surgical Interventions to Alleviate Intraspecific Aggression in Male Collared Lemurs (*Eulemur collaris*). *Journal of Zoo and Wildlife Medicine* **2011**, *42*, 214–221, doi:10.1638/2009-0193.1.

57. Cowl, V.B. The Effects of Captive Management on Primate Social Behaviour and Aggression. Dissertation, University of Manchester, Manchester, UK, 2019.

58. Struhsaker, T.T.; Leland, L. Socioecology of Five Sympatric Monkey Species in the Kibale Forest, Uganda. *Advances in the Study of Behavior* **1979**, *9*, 159–228.
59. Riggio, G.; Pirrone, F.; Lunghini, E.; Gazzano, A.; Mariti, C. Zookeepers' Perception of Zoo Canid Welfare and Its Effect on Job Satisfaction, Worldwide. *Animals* **2020**, *10*, 1–11, doi:10.3390/ani10050916.
60. Hill, S.P.; Broom, D.M. Measuring Zoo Animal Welfare: Theory and Practice. *Zoo Biol.* **2009**, *28*, 531–544, doi:10.1002/zoo.20276.
61. Hosey, G.R.; Melfi, V.; Pankhurst, S. *Zoo Animals: Behaviour Management and Welfare*, 2nd ed.; Oxford University Press: Oxford, UK, 2013; ISBN: 978-0-19-969352-8.
62. Schapiro, S.J.; Lambeth, S.P.; Jacobsen, K.R.; Williams, L.E.; Nehete, B.N.; Nehete, P.N. Physiological and Welfare Consequences of Transport, Relocation, and Acclimatization of Chimpanzees (*Pan troglodytes*). *Appl. Anim. Behav. Sci.* **2012**, *137*, 183–193, doi:10.1016/j.applanim.2011.11.004.