

Morphological, Morphometric, and Health Assessment of Adult Pre-Release Siamangs (*Symphalangus syndactylus*) in Indonesia

Kamila Alawiyah^{1*}, Restu Nova Izati², Selly Novrianti³, & Indra Yustian⁴

^{1,2,4}Department of Biology, Faculty of mathematics and natural science, Universitas Sriwijaya, Indonesia

³Siamang Rehabilitation Center (PRSS), Punti Kayu, Palembang, South Sumatra, Indonesia.

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*Corresponding Email: kamilaalawiyah@mipa.unsri.ac.id

Abstract

Siamangs (*Symphalangus syndactylus*) are endangered arboreal primates whose rehabilitation requires comprehensive health assessments prior to reintroduction. This study fills an important knowledge gap by providing baseline morphological, morphometric, and physical health data for rehabilitated adult siamangs undergoing pre-release evaluation at the Punti Kayu Rehabilitation Center, South Sumatra, Indonesia. Morphological observations and morphometric measurements were conducted during routine veterinary examinations of two adult male siamangs. Parameters included body measurements, body weight, dental characteristics, and general physical health indicators. Both individuals exhibited normal physical conditions, including healthy eyes, intact dentition, and body weights of 9.56 and 9.27 kg, which fall within the reported range for adult siamangs. Slight differences in body dimensions were observed, with one individual exhibiting larger morphometric values. Although the sample size was limited to two adult males, the findings should be interpreted as preliminary but provide valuable baseline information on the morphology, morphometry, and health status of rehabilitated siamangs. These findings can support veterinary health monitoring, improve pre-release assessments, and contribute to evidence-based conservation and rehabilitation strategies for this endangered primate.

Keywords: Wildlife rehabilitation; Conservation biology; Veterinary examination; Arboreal primates; Reintroduction

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INTRODUCTION

Indonesia, as one of the world's megabiodiversity countries, harbors rich tropical forest ecosystems that support high primate diversity. However, increasing anthropogenic pressures including deforestation, habitat fragmentation, and illegal wildlife trade have led to significant population declines and disruption of ecological processes. Primates, which play crucial roles in seed dispersal and forest regeneration, are particularly affected, and their decline may trigger cascading impacts on forest structure and long-term ecosystem stability (Yolanda et al., 2026). One species heavily impacted is the siamang (*Symphalangus syndactylus*), an arboreal primate endemic to Sumatra and the Malay Peninsula. The species is currently classified as Endangered on the IUCN Red List and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), indicating that international commercial trade is strictly regulated because of its high risk of extinction in the wild (IUCN, 2024). Ongoing habitat loss and illegal capture for the pet trade have caused substantial population declines, highlighting the urgency of effective conservation strategies. In response, institutions such as the Balai Konservasi Sumber Daya Alam (BKSDA) conduct wildlife rescue and rehabilitation, where confiscated individuals undergo medical treatment and behavioral recovery prior to potential reintroduction (Sigalingging et al., 2025; Alawiyah et al., 2026).

Wildlife rehabilitation centers therefore play a critical role in restoring the physical and behavioral condition of rescued animals before release. One such facility is the siamang rehabilitation center at Punti Kayu Forest Park, Palembang, South Sumatra, where individuals undergo a series of rehabilitation procedures and health evaluations. Pre-release assessments typically include veterinary examinations, behavioral observations, and physical evaluations to determine whether individuals possess sufficient physiological condition and functional capacity to survive in natural environments. These procedures are consistent with the IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013), which recommend comprehensive assessments of animal health, physical condition, and behavior to maximize post-release survival while minimizing risks to both the released individuals and recipient populations. In addition, the evaluation of adult morphological and morphometric characteristics provides valuable information on somatic



development, biological maturity, and structural adaptation, all of which are closely associated with developmental status and post-rehabilitation fitness. Morphology, morphometrics, and physical health were selected as the primary indicators in this study because they provide objective and measurable information on body structure, somatic development, nutritional condition, and the presence of physical abnormalities. Collectively, these indicators provide a practical and scientifically supported basis for evaluating the physical readiness of rehabilitated individuals prior to release, particularly in arboreal primates whose survival depends on efficient locomotion, climbing ability, and adaptation to complex forest environments. Among these, morphometric measurements provide essential baseline information on body structure, physical condition, somatic growth status, and potential abnormalities, which are particularly important for arboreal primates whose survival depends on effective locomotion and environmental adaptation (Carpino et al., 2025). This approach is also supported by international rehabilitation studies, which emphasize standardized veterinary examinations and physical assessments as fundamental components of evidence-based pre-release evaluation and conservation management (Fuller et al., 2021; Cheyne et al., 2023).

Despite their importance, most studies on siamangs have focused on behavioral ecology and wild populations, while morphometric and health-related data from rehabilitation settings remain limited and rarely documented. This lack of systematic data constrains the development of standardized criteria for assessing physical readiness prior to reintroduction (Fuller et al., 2021; Langgeng et al., 2025). Therefore, this study aims to evaluate the morphometric characteristics and health condition of rehabilitated siamang (*Symphalangus syndactylus*) individuals during pre-release veterinary examinations at the Punti Kayu Rehabilitation Center. The novelty of this study lies in providing baseline morphometric and health data derived from a rehabilitation context, which remains scarce in the literature. The study also provides reference information on adult morphology that may support developmental biology research on primates, while contributing to conservation management and improving assessment protocols for siamang reintroduction programs.

RESEARCH METHODS

This study was conducted from 11 June to 11 July 2025 at the siamang rehabilitation facility located in Punti Kayu Forest Park (Taman Wisata Alam Punti Kayu), Palembang, South Sumatra, Indonesia. The rehabilitation center operates under the supervision of the South Sumatra Natural Resources Conservation Agency (Balai Konservasi Sumber Daya Alam; BKSDA). The facility is situated within the Punti Kayu Nature Tourism Park conservation area, which functions as an important site for wildlife rehabilitation, conservation, and environmental education. The Punti Kayu Forest Park is geographically located between 104°40'05"–104°43'20" East longitude and 2°56'30"–2°57'00" South latitude. The Punti Kayu Forest Park is situated in Alang-Alang Lebar District, Palembang City, South Sumatra Province, Indonesia. The area is managed by Conservation Section I Sekayu under the South Sumatra Natural Resources Conservation Agency. The park consists primarily of lowland tropical forest dominated by *Pinus merkusii*, interspersed with secondary forest vegetation. As one of the few remaining forested areas within the urban environment of Palembang, Punti Kayu Forest Park serves as an important conservation habitat for a variety of wildlife species. Within this conservation area, the siamang rehabilitation facility functions as a temporary center for rescued or confiscated siamangs undergoing rehabilitation and veterinary evaluation prior to potential reintroduction into their natural habitats. At this center, individuals receive a series of health examinations, behavioral monitoring, and physical assessments to evaluate their readiness for release. The veterinary examinations and morphometric measurements conducted in this study were part of routine pre-release health assessment procedures implemented by the rehabilitation management team.

This study involved two adult male siamangs (*Symphalangus syndactylus*), locally identified as Ma Ung and Jay, who were undergoing routine veterinary examinations as part of the pre-release evaluation process at the rehabilitation center. Both individuals had previously been relocated and subsequently underwent a period of rehabilitation to ensure proper care and recovery. At the time of the study, both animals had completed rehabilitation and were assessed to determine their suitability as release candidates. Based on estimated age, Jay was approximately 11 years old, while Ma Ung was approximately 10 years old, categorizing both individuals as adults. Only two individuals were included because they represented the entire population of adult siamangs



undergoing routine pre-release veterinary assessment at the rehabilitation center during the study period. No additional individuals meeting the inclusion criteria were available, and no animals were handled solely for research purposes. Prior to morphometric measurement, each siamang individual was anesthetized to ensure safe handling during the examination process. Anesthetic agents consisting of ketamine (0.4 ml) and medetomidine (0.4 ml) were administered intramuscularly in the left hind limb under the supervision of a licensed veterinarian. After adequate sedation was achieved, body weight was measured using a baby scale and recorded in kilograms (kg). The individual was then positioned on a medical examination table for further measurements.

Morphometric measurements were conducted to obtain quantitative data describing body size and body proportions. The measured parameters included arm length, palm length, leg length, foot length, sitting height, and total body length measured from the head to the coccyx. All linear measurements were recorded in centimeters (cm) using a measuring tape and calipers to ensure measurement accuracy. Before data collection, the measuring tape, calipers, and weighing scale were inspected and calibrated according to the manufacturer's instructions to ensure measurement accuracy. Each measurement was carefully documented during the veterinary examination. All morphometric measurements were performed by the same trained observer following a standardized measurement protocol under veterinary supervision to minimize inter-observer variability. Morphological observations were conducted during veterinary examinations to document the external characteristics of the siamang individuals. Observations focused on general body morphology, including body structure, eyes, hands, fingers, teeth, and hair coloration patterns. These observations were intended to record visible morphological traits and to identify any abnormalities in the external physical condition of the individuals (Ario *et al.*, 2019; Vanhoof *et al.*, 2021).

A general medical examination was also performed to assess the condition of the eyes, skin, hair, teeth, and ears as part of the routine health evaluation. Additional background information regarding the individuals was obtained from rehabilitation center records. Visual documentation was collected through photographs and video recordings taken from multiple angles to support morphological description and data verification. All procedures involving animals were conducted as part of routine veterinary examinations performed at the rehabilitation center. Animal handling,



anesthesia administration, and medical examinations were carried out under the supervision of trained personnel and a licensed veterinarian. All procedures followed the standard veterinary protocols implemented at the rehabilitation facility to ensure animal welfare and minimize stress during the examination process. No additional invasive procedures were performed specifically for this research. The study was conducted with permission from the South Sumatra Natural Resources Conservation Agency (BKSDA), and all examinations formed part of the routine conservation and pre-release health assessment program at the rehabilitation center.

Morphological characteristics observed during the examination were analyzed descriptively to describe the external anatomical features of the siamang individuals. Qualitative descriptions were supported by visual documentation obtained during the examination. Morphometric data were analyzed using a descriptive quantitative approach. Measurements obtained for each morphometric parameter were presented as numerical values to characterize the body proportions of each individual. Because the study involved a limited number of individuals, the analysis focused on describing morphometric variation between the examined individuals rather than performing statistical inference. The morphometric data were used to provide baseline information regarding body structure and physical condition relevant to locomotion and functional adaptation in arboreal primates.

RESULTS AND DISCUSSION

Morphometric measurements and veterinary examinations were conducted on two adult male siamangs, identified as Ma Ung (approximately 10 years old) and Jay (approximately 11 years old), undergoing routine health assessments prior to potential release at the rehabilitation facility located in Punti Kayu Forest Park, Palembang, South Sumatra (Figure 1). These examinations were performed to evaluate the morphometric characteristics and overall physical condition of the individuals as part of the pre-release assessment process. Because only two adult male siamangs were available for routine pre-release veterinary examination during the study period, the findings presented here should be interpreted as preliminary baseline information rather than representative of the species as a whole. Nevertheless, rehabilitation-based studies involving endangered

primates are often constrained by limited animal availability, making descriptive baseline data valuable for improving future conservation and rehabilitation programs.



Figure 1. Siamang individual (*Symphalangus syndactylus*) maintained in the rehabilitation enclosure at Punti Kayu Forest Park, Palembang, South Sumatra.

The assessment included several components, consisting of morphometric measurements of body parameters, observations of external physical condition, dental examinations, and body weight recording. These evaluations were conducted to obtain baseline biological information and to determine whether the individuals displayed physical characteristics consistent with healthy adult siamangs. The siamangs examined in this study are part of the rehabilitation program at Punti Kayu Forest Park, where routine veterinary monitoring is carried out prior to potential release into the wild. Following the identification and documentation of the study subjects, detailed morphometric measurements were conducted to quantify several body parameters of the two siamang individuals.

Morphometric Measurements

Morphometric measurements were performed to characterize body size and limb proportions of the two adult male siamangs undergoing rehabilitation at the Punti Kayu Rehabilitation Center. The measurement protocol included arm length, palm length, leg length, foot length, sitting height, head-coccyx length, and body weight. Anatomical landmarks and the measurement scheme are illustrated in Figure 2, in which the anesthetized individuals were positioned in a standardized supine posture to ensure

consistent identification of anatomical reference points and improve measurement accuracy.

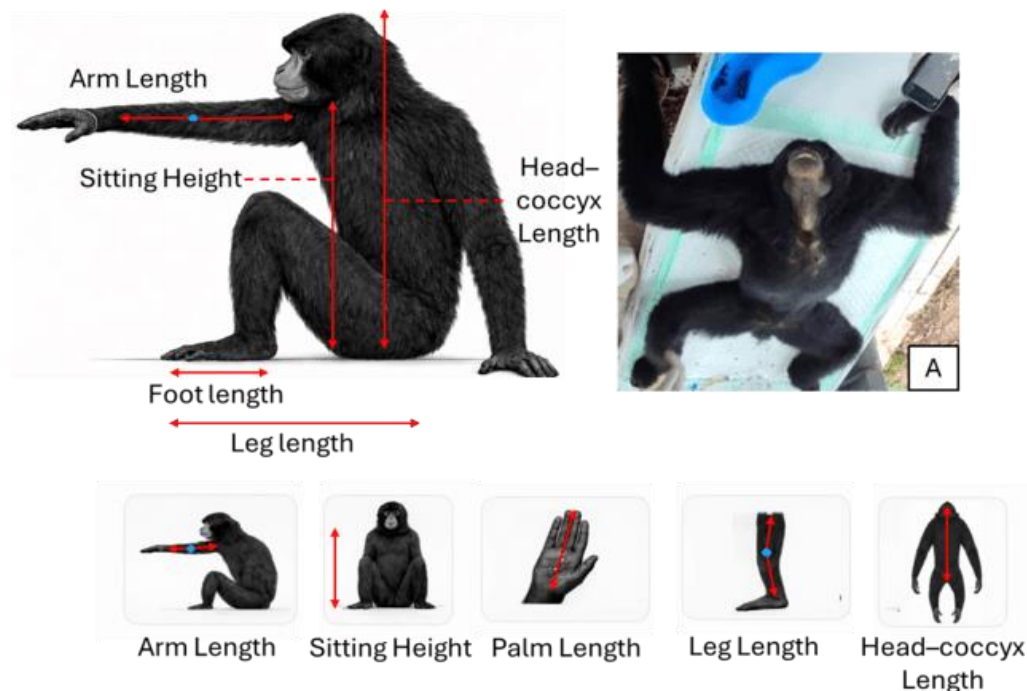


Figure 2. Morphometric measurement of *Symphalangus syndactylus*, diagram illustrating the morphometric parameters measured in this study, including arm length, palm length, leg length, foot length, sitting height, and head-coccyx length. (A) Siamang individual under anesthesia undergoing morphometric measurements during data collection.

The morphometric data revealed generally comparable body proportions between the two individuals, with only slight differences in absolute body dimensions (Table 1). Ma Ung consistently exhibited larger measurements than Jay across most recorded parameters. Total arm length was 63.0 cm in Ma Ung, compared with 58.7 cm in Jay, while total leg length measured 49.0 cm and 44.5 cm, respectively. Similar trends were observed for sitting height (40.0 vs. 38.2 cm), head-coccyx length (50.0 vs. 47.4 cm), and palm and foot length (18.4 vs. 16.4 cm). Body weights were also comparable, measuring 9.56 kg in Ma Ung and 9.27 kg in Jay, values that fall within the reported range for healthy adult siamangs. Although Ma Ung exhibited slightly larger body dimensions, the differences were relatively small and most likely represent normal intraspecific variation associated with individual growth history, nutritional status, and developmental factors rather than pathological conditions. Such variation has also been documented in other hylobatid populations and is considered common among adult individuals. Because both individuals

examined in this study were adult males, the observed morphometric differences are more likely to reflect individual variation than sexual dimorphism. Although siamangs generally exhibit less pronounced sexual dimorphism than many other primates, differences in body size, body mass, and canine development between males and females have been reported. Consequently, additional studies including female individuals are required to establish sex-specific morphometric reference values for rehabilitated siamangs (Balolia, 2021).

Table 1. Morphometric measurements of two adult male siamangs examined at the Punti Kayu rehabilitation facility

Morphometric Parameter		Ma Ung (cm)	Jay (cm)
Arm Length	Wrist-Elbow	29	27.2
	Elbow-Shoulder	34	31.5
Total Arm Length		63	58.7
Leg Length	Ankle-Knee	24.5	22
	Knee-Hip	24.5	22.5
Total Leg Length		49	44.5
Palm Length		18.4	16.4
Foot Length		18.4	16.4
Sitting Height		40	38.2
Head-Coccyx Length		50	47.4

Despite differences in absolute size, both siamangs displayed remarkably similar body proportions. In particular, forelimbs were substantially longer than hindlimbs in both individuals, a defining morphological characteristic of hylobatid primates. This limb configuration represents a well-established anatomical adaptation for brachiation, allowing efficient suspensory locomotion through the forest canopy. The preservation of these proportional relationships suggests that both rehabilitated individuals retained normal musculoskeletal development and structural adaptations necessary for arboreal movement. Palm and foot dimensions were also proportionally well developed in both individuals. These structures play an important role in grasping branches and maintaining stability during locomotion in arboreal habitats. Although the recorded values were slightly greater than those reported in some previous studies, the proportional relationship among limb segments remained consistent, indicating normal morphological development rather than abnormal enlargement. Nevertheless, because locomotor performance and biomechanical function were not assessed, these measurements should be interpreted as descriptive morphological indicators rather than direct evidence of functional competence (Vanhoof et al., 2021).



Ontogenetic variation should also be considered when interpreting these findings. Since both examined individuals were adults, the morphometric measurements primarily represent mature body proportions and cannot be generalized to juvenile or subadult siamangs. Morphometric changes occurring during growth and development are important for understanding age-related variation and may provide additional information for determining rehabilitation progress and release readiness across different life stages. The proportional relationship between forelimbs and hindlimbs observed in both individuals also reflects ecological adaptation to an arboreal lifestyle. Long forelimbs, well-developed hands, and grasping feet are essential anatomical adaptations that facilitate brachiation, climbing, and efficient movement through the forest canopy. Preservation of these characteristics during rehabilitation is therefore important because they contribute to the functional abilities required for survival following reintroduction into natural habitats (IUCN, 2013; Vanhoof et al., 2020; Alawiyah et al., 2026).

Physical Condition

The physical condition of the two adult male siamangs was assessed through external examination during routine veterinary health checks (Table 2). The assessment included eye condition, fur and skin appearance, ear cleanliness, palm and foot condition, dentition, and overall external physical characteristics to identify visible health-related conditions prior to release.

Table 2. Physical indicators used in pre-release health assessment of siamangs

Parameter	Ma Ung	Jay	Interpretation
Eye condition	Normal	Normal	Indicates absence of infection or ocular disease
Fur condition	Tangled	Tangled	Likely influenced by environmental or grooming behavior
Skin condition	Dirty	Dirty	No visible lesions observed
Dentition	Complete	Complete	Suitable for natural feeding behavior
Ear cleanliness	Clean	Dirty	Requires minor cleaning and monitoring
Body weight	9.56 kg	9.27 kg	Within normal range for adult siamangs
General physical condition	Good	Good	Suitable for rehabilitation monitoring

The examination indicated that both individuals generally exhibited normal external physical characteristics. Both siamangs had dense black fur, which is the typical coat coloration of the species. Although the fur appeared slightly tangled and the skin somewhat dirty, no visible signs of excessive hair loss, skin lesions, or other apparent



dermatological abnormalities were observed. These conditions may reflect environmental exposure within semi-natural rehabilitation enclosures rather than underlying health disorders. Both individuals exhibited clear brown eyes without obvious external abnormalities. Eye condition is commonly included in routine veterinary examinations because visible ocular changes may indicate systemic illness, nutritional imbalance, or infection. Ear condition differed slightly between individuals, with Ma Ung presenting cleaner ears than Jay. However, no apparent signs of inflammation, discharge, or other visible abnormalities were detected during the examination. Slight cracking of the palm and foot pads was observed in both individuals. Given the arboreal lifestyle of siamangs, these minor surface changes may be associated with regular locomotor activity and frequent contact with enclosure substrates (Wiseman et al., 2026).

Nevertheless, additional clinical or behavioral evaluation would be required to determine their functional significance. The physical observations were consistent with the morphometric assessment, in which both individuals exhibited body weights within the reported range for adult siamangs. Collectively, these findings suggest that the two rehabilitated individuals showed generally normal external physical condition at the time of examination. However, external physical assessment alone cannot determine overall health status or release suitability and should therefore be interpreted alongside veterinary, behavioral, and ecological evaluations as part of a comprehensive pre-release assessment. These findings are also consistent with the IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013), which recommend that release decisions should be supported by comprehensive veterinary, behavioral, and ecological assessments. Accordingly, the morphometric, physical, and dental evaluations presented in this study represent complementary components of a multidisciplinary framework for assessing the readiness of rehabilitated siamangs prior to release.

Dental Measurements

Dental examination was conducted to evaluate the condition and dimensions of the canine teeth in the two adult male siamangs during routine veterinary assessment. Measurements of the upper and lower canines on both the left and right sides were



obtained using a precision caliper and recorded in millimeters (Table 3), while the overall dental condition was documented through direct observation (Figure 3).

Table 3. Dental Measurements of Siamangs

Dental Parameter	Ma Ung (mm)	Jay (mm)
Upper right tooth	21	20.5
Upper left tooth	21.5	20.5
Lower right tooth	14.5	11
Lower left tooth	13	10.5

The dentition of both individuals appeared complete and structurally intact throughout the examination, corresponding to the typical primate dental formula (2.1.2.3). Canine measurements showed only slight differences between individuals, with Ma Ung generally exhibiting larger values than Jay. The largest canine measurement was recorded for the upper left canine of Ma Ung (21.5 mm), whereas the smallest was observed for the lower left canine of Jay (10.5 mm). In both individuals, the upper canines were consistently larger than the lower canines, a pattern that is consistent with normal dental morphology in adult primates.

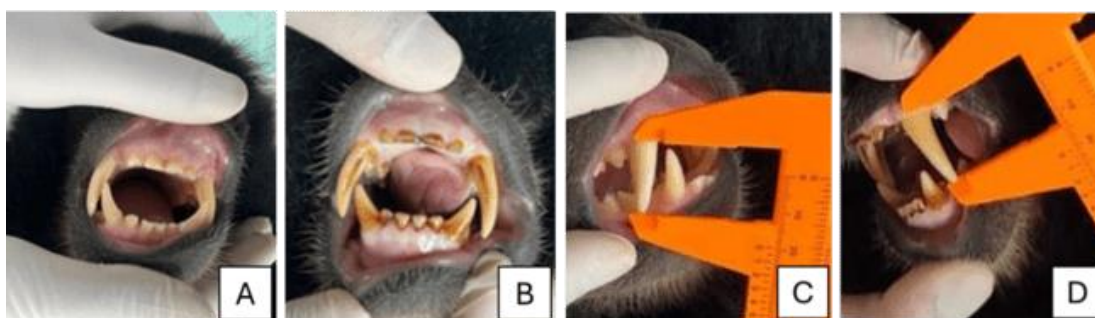


Figure 3. Dental examination and canine measurement of two adult male siamangs.

(A, C) Dental observation and canine measurement of Ma Ung.

(B, D) Dental observation and canine measurement of Jay. Measurements were obtained using a precision caliper during veterinary assessment.

Differences in canine size between Ma Ung and Jay were relatively small and are likely to reflect normal individual variation rather than abnormalities in dental development. Likewise, although Ma Ung exhibited slightly cleaner teeth than Jay, no obvious evidence of severe tooth wear, fractures, caries, or other visible dental abnormalities was observed during the examination. Dental condition is commonly included in pre-release veterinary assessments because healthy dentition is important for food acquisition and processing in free-ranging primates (Cofran & Boughner, 2025). Although functional feeding performance was not evaluated in this study, the observations indicate that both individuals possessed complete and externally intact dentition at the time of examination. The dental measurements reported here therefore

provide descriptive baseline data that complement morphometric and physical health assessments and may serve as reference information for future monitoring of rehabilitated siamangs.

Study Limitations and Future Directions

Overall, the morphometric, physical, and dental assessments provide complementary descriptive information on the two rehabilitated adult siamangs examined in this study. Despite the limited scope of the observations, the findings contribute valuable baseline information that may support future monitoring, comparative studies, and the development of pre-release assessment protocols for rehabilitated siamangs. This study has several limitations that should be considered when interpreting the findings. First, only two adult male siamangs were available for examination because the study was conducted during routine pre-release veterinary assessments at the rehabilitation center. Consequently, the results should be interpreted as preliminary and cannot be generalized to the broader population of *Symphalangus syndactylus*. Second, the inclusion of only adult males precluded the evaluation of sexual dimorphism and ontogenetic variation in morphometric characteristics. Third, this study focused primarily on morphometric, dental, and external physical assessments without evaluating behavioral competence, locomotor performance, physiological indicators, or post-release survival, all of which are important components of comprehensive pre-release assessment recommended by the *IUCN Guidelines for Reintroductions and Other Conservation Translocations* (IUCN/SSC, 2013).

Future studies should therefore include larger sample sizes encompassing both sexes and multiple age classes to establish more representative morphometric reference values for rehabilitated siamangs. Longitudinal monitoring throughout the rehabilitation process and after release would provide valuable information on changes in body condition, behavioral adaptation, and post-release survival. Furthermore, integrating morphometric assessments with behavioral, physiological, genetic, and ecological evaluations would provide a more comprehensive framework for assessing release readiness and strengthening evidence-based conservation and rehabilitation strategies for *Symphalangus syndactylus*.



CONCLUSION

This study provides descriptive morphometric, physical, and dental data for two adult male siamangs (*Symphalangus syndactylus*) undergoing rehabilitation at the Punti Kayu Rehabilitation Center. The two individuals exhibited generally comparable body proportions, complete dentition, and external physical characteristics, with only minor individual variation in morphometric and dental measurements. Body weights were also within the reported range for adult siamangs. These observations contribute baseline information on the morphology and external physical condition of rehabilitated siamangs during veterinary evaluation. Although limited to two individuals, the findings may serve as reference data for future monitoring and comparative studies in rehabilitation settings. Further research involving larger sample sizes, longitudinal observations, and integration of behavioral and functional assessments is needed to improve the understanding of rehabilitation outcomes and to strengthen pre-release evaluation protocols.

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