

## RESEARCH ARTICLE



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# First Analysis of the Rehabilitation and Release Facilities for Javan Hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924) in Indonesia

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## Abstract

The Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924), an endangered bird endemic to Java island, faces significant extinction risks due to habitat loss and illegal hunting. To address this, the Javan Hawk-eagle Sanctuary Center (JHESC) was established within Mount Halimun Salak National Park, Bogor Regency, West Java, Indonesia, to support in-situ and ex-situ conservation efforts, focusing on rehabilitation and release. This study observed rehabilitation practices at the centre from April 2022 to March 2023, particularly the adequacy of its facilities and infrastructure regarding cage, feed, and health management. These aspects are essential for rehabilitation success. Based on observations, nine cage types were employed and tailored to specific rehabilitation stages: acceptance, treatment, isolation, pre-training, training, habituation, education, translocation, and hard release. These cages were designed with varying sizes and numbers to fulfil the needs of each stage. The centre's feeding management was supported by a well-organized storage system that maintained feed quality through proper air circulation and cleanliness. The centre consistently supplied three primary feeds: mice (*Mus musculus*), rats (*Rattus norvegicus*), and marmots (*Cavia porcellus*). Comprehensive infrastructure facilitated health management, including an animal clinic, isolation and treatment rooms, an operating room, an examination room, and a laboratory. Additionally, the veterinary medicines were accessible and staffed by qualified veterinarians to ensure the eagles were healthy from arrival to release. These robust facilities and practices can position the centre as a leading example for ex-situ conservation, prioritizing animal welfare while rehabilitating and releasing Javan hawk-eagles, with expectations of further enhancing eagle conservation efforts.

Keywords: Javan hawk-eagle, Javan Hawk-eagle Sanctuary Center, management standard, rehabilitation, release program

## 1. Introduction

The Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924) is a protected raptor species in Indonesia according to government regulation number 7 in 1999 and the regulation of the Minister of Environment and Forestry number P.106 in 2018 [1–4]. This protection status is inextricably linked to the Javan hawk-eagle's significant contribution to the ecosystem's stability and balance as a primary consumer in the food chain. Furthermore, its wild existence is currently at risk of extinction owing to habitat destruction, poaching, illegal trade, and small population size [5–10]. The total population of wild Javan hawk-eagles is estimated to be approximately 511 pairs in 2023. Additionally, the Indonesian government has designated this species as one of the 25 priority conservation species, recognizing the significance of its preservation in the future [11].

The Indonesian government has implemented various in situ and ex situ conservation programs for the Javan hawk-eagle to address the increasing threats to its survival and its

essential role in maintaining ecosystem stability. These efforts encompass habitat restoration, strict law enforcement against poaching and illegal trade, and the rehabilitation of confiscated Javan hawk-eagles. Additionally, voluntary handovers by the public facilitate the reintroduction of rehabilitated individuals into their natural habitat [12,13].

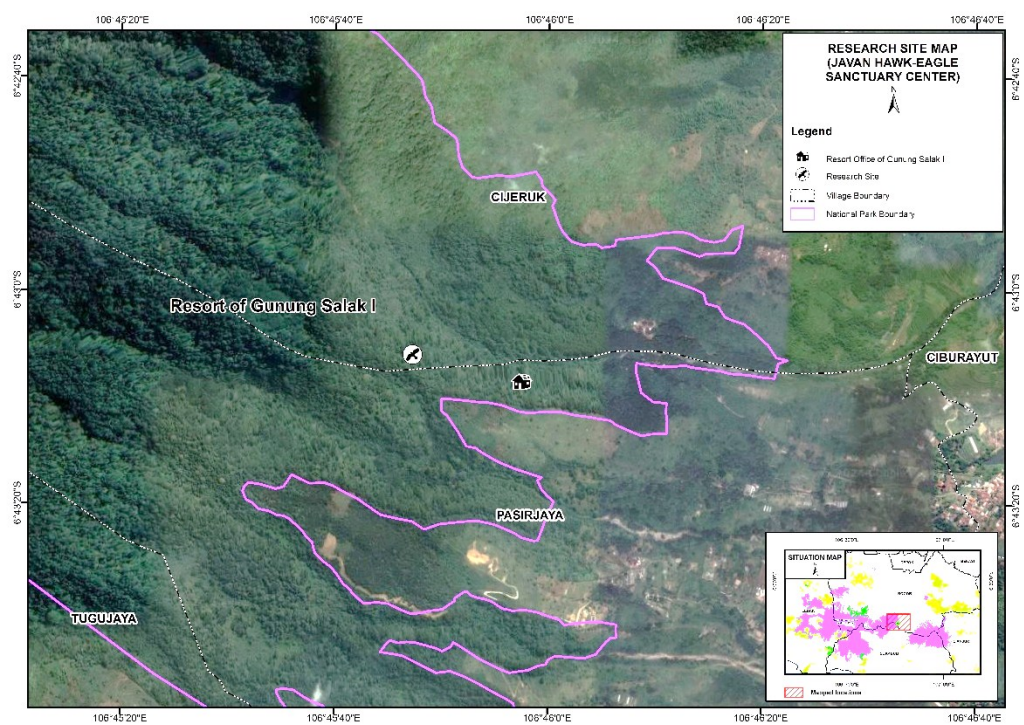
Moreover, the Indonesian Government's commitment to Javan hawk-eagle preservation was demonstrated by the Minister of Forestry regulation number P.58 of 2013 in 2013 regarding the strategy and conservation action plan for the Javan hawk-eagle during 2013-2022 [14]. In Indonesia, ex-situ conservation initiatives for the Javan hawk-eagle have been effectively implemented by two institutions in West Java Province: the Javan Hawk-eagle Sanctuary Center (JHESC) in Mount Halimun Salak National Park, Bogor Regency, and the Kamojang Eagle Conservation Center in Kamojang Nature Tourism Park, Garut Regency. Established in 2007, JHESC focuses on rehabilitating Javan hawk-eagles and other eagle species to support their eventual release into the wild [15,16]. The Kamojang Eagle Conservation Center, founded in 2014, shares the same mission as its predecessor, JHESC, in promoting the conservation and rehabilitation of eagle species [17].

The JHESC represents the pioneering conservation organization in Indonesia with extensive expertise in rehabilitating and releasing Javan hawk-eagles and other eagle species. Consequently, it can be used as a reference for the best practices for managing these species. However, it is essential to acknowledge the lack of comprehensive studies and information regarding management standards, including the quality of facilities for the rehabilitation and release of Javan hawk eagles. Infrastructure and facilities are crucial for the rehabilitation and release of these species. Based on this information, it is crucial to observe the infrastructure and facilities for the rehabilitation and release of Javan hawk-eagles in JHESC as the best practice that can be used as a benchmark for the compilation of infrastructure and facilities for the rehabilitation and release of Javan hawk-eagles in Indonesia, with an emphasis on animal welfare. Therefore, we aimed to analyze the management of facilities and infrastructure at the JHESC, encompassing cage, feed, and health management.

## 2. Materials and Methods

This study was conducted at the Javan Hawk-eagle Sanctuary Center (JHESC), a conservation center dedicated to rehabilitating and releasing raptor species, with a particular emphasis on Javan hawk-eagles, back into the wild (Figure 1). JHESC is located in Bogor Regency, West Java Province, Indonesia, within the Mount Halimun Salak National Park. The center also provides a platform for conservation education, including limited ecotourism, research, and science development, especially on raptors. Based on our experiences in rehabilitating Javan hawk-eagles, we selected the JHESC as a study location to analyze rehabilitation and release standards, particularly in terms of the use and selection of infrastructure and facilities.

We collected and analyzed data from April 2022 to March 2023. We documented the type, number, size, function, and position of the facilities and infrastructure in the JHESC. This study focused on the cage, feed, and health management aspects (Table 1). In this analysis, we combined all observational data from each management aspect. Subsequently, we analyzed the data using a qualitative descriptive analysis.



**Figure 1.** The Javan Hawk-eagle Sanctuary Center (JHESC) facility at the Mount Halimun Salak National Park, Bogor Regency, West Java Province, Indonesia.

**Table 1.** Type of collected data and method.

Aspect of Management	Data Type	Method
Cage	Type, number, size, function, material, and position of cages	Direct observation and measurement
Feed	Type, number, size, function, material, and position of building related to feed management	Direct observation and measurement
Health	Type, number, size, function, material of building related to health management, availability of equipment, materials, types of medicines	Direct observation and measurement

**3. Results and Discussion**

**3.1. Result**

**3.1.1. Cage Management**

An essential factor in the successful rehabilitation and release of Javan hawk-eagles is the management of their cages, which prioritizes the welfare and needs of animals. Based on observations, the Javan Hawk-Eagle Sanctuary Center (JHESC) had nine distinct types of cages with various sizes, materials, numbers, and functionality. The nine types of cages were acceptance, treatment, isolation, pre-training, training, habituation, education, translocation, and hard release (Table 2).

Newly arrived eagles at the JHESC were placed in acceptance cages for assessment to determine whether they would be rehabilitated or released. Three small acceptance cages were used to limit movement and prevent further injury to the injured or ill eagles, thereby promoting their recovery. Additionally, the center was equipped with two treatment cages for eagles with injuries or wounds and two isolation cages for those testing positive for infectious diseases. The compact size of both the treatment and isolation cages was

strategically designed to optimize the allocation of the energy of the eagles towards the healing process, minimizing movement and flight.

Once the eagle demonstrated readiness for advanced rehabilitation, it was transferred to a larger pre-training cage to facilitate the perching practice. JHESC maintained eight pre-training cages for this purpose (Figure 2). Following this stage, eagles were moved to training cages, which were spacious enough to allow for flight practices and the exhibition of natural behaviors, featuring a floor covered in forest vegetation. Additionally, eagles that could not be released due to age or disability were housed in educational cages measuring 4 x 6 x 3.5 m, of which there were five. These educational cages served as a platform for conservation education, allowing visitors to the JHESC to learn about eagle conservation.

Furthermore, three small translocation cages were used to securely transport eagles to the release site. Before release, habituation cages (3 x 3 x 4 m) were temporarily stationed at the release site to assist eagles in acclimating to their natural environment (Figure 2). JHESC also implemented a release mechanism involving specialized small cages (1 x 1.5 x 1.7 m), with one cage available for facilitating direct release without the need for prior habituation.

All materials used in constructing the cages at JHESC were carefully chosen to ensure the safety of the eagles and to minimize the risk of injury during transport. The materials selected included iron pipes for poles and frames, and nylon nets for acceptance, treatment, isolation, pre-training, training, education, and hard-release cages. Wooden or bamboo netting materials were selected for the habituation cages, and plastic boxes were specifically designed for use in the translocation cages. In addition to using eagle-safe materials, CCTV systems have been installed in several cages to facilitate real-time monitoring throughout the rehabilitation process.

**Table 2.** Type, material, size, number, and function of cages in the Javan Hawk-eagle Sanctuary Center (JHESC).

No	Cage Type	Material	Size (l x w x h)	Number	Function
1	Acceptance	Iron pipe, net	1 x 1 x 1 m	3	Placing newly arrived eagles before assessment
2	Treatment	Iron pipe, net	1 x 1.5 x 1 m	2	Placing eagles that require post-assessment care
3	Isolation	Iron pipe, net	1 x 1.7 x 1 m	2	Placing eagles that require further medical care and treatment and prevent the spread of disease in the eagle
4	Pre-training	Iron pipe, net	2 x 1 x 2 m	8	As an initial stage of rehabilitation, treatment is given to train early wild behavior
5	Training	Iron pipe, net	20 x 10 x 15 m	9	Advanced stage of rehabilitation to improve advanced wild behavior skills
6	Habituation	Wood/ bamboo, net	3 x 3 x 4 m	Following release activities	Placing eagles that will be released to acclimatize to the environmental conditions of the release site
7	Education	Iron pipe, net	4 x 6 x 3.5 m	5	Conservation education tool for visitors
8	Translocation	Plastic box	0.7 x 0.5 x 0.3 m	3	Carrying the eagle during translocation
9	Hard release	Iron pipe, net	1 x 1.5 x 1.7 m	1	Used during the hard release method of release

Note: l = long, w = width, h = height





**Figure 2.** Structures of the cages. (A) Pre-training cages, (B) Training cages, (C) Education cages, (D) Habituation cages.

### 3.1.2. Feed Management

Feed management is another factor in the rehabilitation process of Javan hawk-eagles, as the consistent provision of nutritious, high-quality feed significantly contributes to successful outcomes. Observations regarding feed management at JHESC revealed the presence of a dedicated feed warehouse measuring  $3 \times 4 \times 4$  m, used for storing eagle feed during the rehabilitation process, and equipped with air vents and exhaust fans for proper ventilation (Figure 3). The warehouse was cleaned regularly to ensure feed quality and to prevent the spread of germs and diseases. Additionally, its location was a significant distance from the rehabilitation cages, with the nearest being approximately 20 m away and the farthest around 200 m.

JHESC provided three types of feed for the eagles: mice (*Mus musculus*), rats (*Rattus norvegicus*), and marmots (*Cavia porcellus*), with a daily composition of 300 g (e.g., two mice, one rat, or one guinea pig). Feeding occurred once daily, with feed types always alternating daily, and only white-colored feed was used. Cahaya et al. previously studied the nutritional content of these feed types [18], as summarized in Table 3.



**Figure 3.** Feed management owned by JHESC. (A) Feed warehouse, (B) Eagle feed condition.

**Table 3.** Nutrient content of three eagle feed types.

Nutrient Content	Feed Type		
	Rats	Mice	Marmot
Fat (%)	1.85 ± 0.47	64 ± 1.62	47 ± 1.77
Protein (%)	16.19 ± 0.16	15.59 ± 0.70	14.63 ± 0.43
Calcium (%)	0.66 ± 0.07	0.71 ± 0.16	1.57 ± 0.62
Phosphorus (%)	0.36 ± 0.05	0.33 ± 0.04	0.40 ± 0.05
Total energy (KCal)	1.66 ± 0.09	2.00 ± 0.07	1.32 ± 0.08

Source: Cahaya [18]

3.1.3. Health Management

Javan hawk-eagles' health management is an important factor in their rehabilitation, encompassing the period from arrival to release. Observations indicated that JHESC had various facilities and infrastructure with varying functions to support the health of eagles, including an animal clinic, isolation and medicine rooms, an operating room, an examination room, and a laboratory (Table 4). Additionally, the JHESC management provided various medical supplies and drugs to address illnesses or infections that may arise during the rehabilitation process (Discussion

The Javan Hawk-Eagle Sanctuary Center (JHESC) functions as a specialized conservation facility dedicated to the rehabilitation and ex-situ release of eagles outside their natural habitat [15,16]. This designation aligns with Minister of Environment and Forestry Regulation No. P.22 of 2019 stipulates that this type of conservation center may be operated by governmental or non-governmental entities, primarily focusing on animal rescue and rehabilitation [19]. The JHESC infrastructure, comprising cages, health facilities, and auxiliary buildings, is essential for successful rehabilitation efforts. The quality of these facilities was reflected in the "very good" welfare rating of rehabilitated eagles [20].

Cage management at the JHESC is pivotal to the welfare of eagles during rehabilitation. The enclosures were constructed using safe materials such as iron pipes and weather-resistant nylon nets to minimize injury risks while ensuring comfort and safety. Proper cage dimensions and materials significantly affect rehabilitation outcomes and animal welfare [21]. Cage sizes are tailored to specific rehabilitation stages, providing adequate space for social interaction and mitigating the risks of disease transmission [22]. The diverse cage sizes at JHESC accommodated the unique needs of each eagle during rehabilitation.

**Table 5).**

Beyond infrastructure, the JHESC was supported by skilled personnel, including veterinarians and trained assistants, who were consistently available to address eagle health issues throughout rehabilitation. Medical staff conducted thorough health assessments upon arrival of the eagles, including morphometric evaluations, physical examinations, and infectious disease testing, continuing until the eagles were prepared for release. Sick eagles would receive targeted treatment based on these health assessments to ensure appropriate care. The integration of comprehensive facilities and qualified medical staff at the JHESC is intended to enhance the success of rehabilitation and release initiatives, contributing to the ex situ conservation of the Javan hawk-eagle.

**Table 4.** Animal health support facilities in the Javan Hawk-eagle Sanctuary Center (JHESC).

Type of Facility	Description of Function
Animal Clinic	A building that accommodates all activities to support animal health management in the rehabilitation center.
Isolation room	An exclusive room is provided to store animals undergoing health care so that treatment can be carried out intensely and disease transmission does not occur
Medicine room	An exclusive room used for medicine storage
Operation room	An exclusive room used to perform surgery on animals.
Examination room	An exclusive room used to conduct routine checks on animals.

Laboratory	An exclusive room containing all laboratory equipment used to conduct laboratory testing for a particular sample
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3.2. Discussion

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Table 5. List of medicines in the Javan Hawk-eagle Sanctuary Center (JHESC) animal clinic.

No	Type of Medicine	Description
1	Antibiotics	Amoxiclav, clindamycin, Gentamicin, Oxytetracycline hydrochloride, Penicillin procaine, Metronidazole
2	Anti-pain	Meloxicam
3	Anti-inflammatory	Dexamethasone
4	Eye ointment	Erlamycetin
5	Mouth ointment	Triamcinolone acetonide
6	External wound ointment	Gentamicin sulfate, Hydrocorticone
7	Antiseptic	70% Alcohol, Providone iodine
8	Multivitamins	Vitamin A, Vitamin D3, Vitamin E, Vitamin B2, Vitamin B6, Vitamin B12, d-Panthenol, Nctnamide
9	Vitamin B1	Vitamin B1
10	Vitamin K	Vitamin K
11	Anesthesia	Zoletil, Ketamine
12	Intravenous fluids	NaCl, Lactated Ringer
13	Electrolyte fluids	L NA, K, Cl, Citrate, Dextrose
14	Analgesics	Atropine
15	Anti-parasitic	Ivermectin
16	Anti-fungal	Ketoconazole

Rehabilitation began with a veterinary health assessment of the newly arrived eagles to determine their condition. Healthy individuals were placed in pre-training enclosures, while sick or injured individuals were assigned to treatment cages. Eagles diagnosed as contagious diseases were isolated to prevent transmission. The treatment and isolation cages were intentionally small to limit mobility and prioritize recovery, allowing intensive monitoring by veterinarians.

Eagles deemed healthy progress to pre-training, where efforts focused on reintroducing natural behaviors. Subsequently, they were transferred to training cages designed to mimic natural environments and to provide sufficient space for flight training and acclimatization. According to wildlife rehabilitation standards, large training cages (e.g., 9.1 x 3 x 3.7 m) facilitated behavioral recovery and environmental adaptation [21]. These cages feature forest vegetation flooring, which encourages wild foraging. Despite the availability of nine training cages, this number remained relatively low compared with the number of eagles requiring training.

Upon completion of the training, eagles ready for release were transported to the release site in specialized translocation cages. Habituation cages, made from iron frames with plastic fencing and shaded by foliage, were acclimatized before release. Sometimes, eagles are released directly into the wild or hard-release without habituation. Unreleasable eagles, due to age or disability, were housed in educational cages that met rehabilitation standards and supported conservation awareness programs [23]. Furthermore, school students can directly observe diverse eagles at the JHESC. The critical ecological role of eagles in sustaining the biosphere underscores the importance of maintaining these species in their natural habitats rather than in captivity [24]. These cages at JHESC aligned with minimum standards for limited-movement cages (i.e., 2.4 x 1.8 x 2.4 m) [21].

Facility management at the JHESC emphasizes cleanliness and eagle health. Cages were regularly disinfected to prevent mold and disease, and isolation cages were cleaned more frequently owing to the vulnerability of their occupants. Training cages were cleaned as needed when the vegetation became too dense. Exposure to sunlight is a crucial component of cage hygiene as it inhibits the growth of fungi and bacteria, including aspergillosis-causing agents [25].

JHESC employed closed-circuit television (CCTV) in rehabilitation cages to monitor eagle behavior continuously. This system facilitated the observation of critical behaviors, such as mating and egg-laying, which are essential indicators of rehabilitation success. Regular maintenance ensures system functionality.

Effective feed management is integral to the rehabilitation process at JHESC, ensuring the availability of high-quality, species-appropriate diets. Eagles were given various live prey, including snakes, lizards, and small mammals, to mimic natural feeding behaviors and maintain interest [26]. Nutritional needs were carefully calibrated, with eagles requiring diets comprising 20-30% of their body weight [27]. Feed was sourced from local breeders, and JHESC actively supported and trained these suppliers to ensure consistent feed quality. However, the center was exploring resource expansion to meet increasing food demands.

Health management is also fundamental to eagle rehabilitation at the JHESC, focusing on disease prevention, health monitoring, and adherence to biosecurity protocols. The health management framework incorporates disease detection, diagnosis, and mitigation strategies [28], complying with Government Regulation No. 47 of 2014 on animal disease control. Biosecurity is implemented in the management of eagle health to prevent the entry of eagles into JHESC, which may threaten human health or other eagles. This system is consistent with [21], who asserted that effective animal health management would also prevent disease transmission between humans and animals or between animals. Furthermore, the health management system at JHESC is consistent with government regulation number 47 of 2014 on animal disease control and management, which encompasses the following: observation and identification of animal diseases, prevention of animal diseases, safeguarding of animal diseases, eradication of animal diseases, and treatment of animals [29].

Upon arrival, participants underwent detailed health examinations, including morphometric measurements, physical assessments, and vital checks [20]. Javan hawk-eagle morphology was assessed through this physical and morphometric examination to ascertain its degree of completion. It was uncommon for eagles to have an imperfect morphology when they entered the JHESC, such as beak conditions that could not close completely or with clipped wing feathers. Regular health monitoring was continued throughout the rehabilitation, particularly for eagles in quarantine or transit cages.

During treatment and isolation, eagles were monitored hourly to ensure recovery. In cases of mortality, necropsies were performed to determine the cause of death, with non-infectious specimens used for research and educational purposes, such as those used by the JHESC, other conservation organizations, or universities (e.g., IPB University). Multivitamins were administered to support immune function, particularly before release. Weight management was also prioritized; underweight eagles received additional nutrition, whereas overweight individuals underwent controlled fasting. The health management protocols at the JHESC aimed to ensure eagle welfare throughout the rehabilitation process, minimizing



pain and illness. Skilled veterinarians and staff continuously monitored the health of eagles, contributing to successful rehabilitation outcomes.

Altogether, managing cages, feeding, and health at the JHESC was considered good, as it adhered to established regulations and standards for animal rehabilitation, prioritizing animal welfare. This effectiveness was further demonstrated by the JHESC's success in rehabilitating and releasing eagles in previous years. For instance, in 2019, the center successfully released a changeable hawk-eagle. In 2020, it released four eagles: two changeable hawk-eagles, one crested goshawk, and one crested serpent-eagle. In 2021, 14 eagles were released, including four Javan hawk-eagles, three crested serpent-eagles, six changeable hawk-eagles, and one crested goshawk. In 2022, the center released 22 eagles, including six Javan hawk-eagles, seven changeable hawk-eagles, five crested serpent-eagles, and four Black kites [30]. These successful releases underscored the center's essential role in Eagle conservation. In the future, JHESC is expected to consistently enhance rehabilitation practices by modernizing facilities and management, integrating the latest studies, developing species-specific rehabilitation methods, and conducting post-release studies to evaluate long-term success, support eagle population recovery, and prevent extinction.

In addition to enhancing ex situ conservation efforts, it is imperative to strengthen in-situ conservation initiatives, such as habitat restoration [5], as rehabilitated and released eagles return to their natural environment. Furthermore, the enforcement of stringent legal measures and the promotion of public awareness are essential [31]. These combined efforts aimed to address the challenges associated with the rehabilitation and release of eagles and their long-term conservation within their natural habitats. These efforts were designed to address the challenges associated with future rehabilitation and the release of eagles.

#### 4. Conclusions

The Javan Hawk-Eagle Sanctuary Center (JHESC) is essential for rehabilitating and releasing eagles. The infrastructure, facilities, and management related to the three aspects (cages, feeding, and health) were assessed as good, adequately meeting the requirements of eagles throughout the rehabilitation process until their release. These facilities and management facilities comply with animal welfare regulations and standards, ensuring proper cages and tailored adjustments for individual eagles at each stage, consistent and nutritious feeding, and comprehensive health monitoring with skilled personnel. To enhance rehabilitation success, sustaining these management practices while advancing through modernization, and based on future studies, are essential. Additionally, future studies should focus on developing species-specific rehabilitation methods, as JHESC accommodates not only Javan hawk-eagles, but also other eagle species. Further studies on post-release monitoring of eagles are also necessary to evaluate the long-term success of rehabilitation efforts.

#### Author Contributions

**AHM:** Conceptualization, Methodology, Investigation, Formal Analysis, Writing - Review & Editing; **AMD:** Conceptualization, Methodology, Review & Editing, Supervision; **BHM:** Conceptualization, Methodology, Review & Editing, Supervision; **DMP:** Conceptualization, Methodology, Review & Editing, Supervision

#### Conflicts of interest

The authors declare that they have no conflicts of interest.

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