

# Rehabilitation criteria and indicators for the successful release of Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924)

AHMAD MUNAWIR<sup>1,2,✉</sup>, ANI MARDIASTUTI<sup>3</sup>, BURHANUDDIN MASY'UD<sup>3</sup>,  
DEWI MALIA PRAWIRADILAGA<sup>4</sup>

<sup>1</sup>Program of Tropical Biodiversity Conservation, Faculty of Forestry and Environment of Forestry and Environment, Institut Pertanian Bogor. Jl. Ulin-Lingkar Akademik, Dramaga, Bogor 16680, West Java, Indonesia. Tel.: +62-251-8621947, ✉email: wiratns@gmail.com

<sup>2</sup>Directorate of Conservation Area Planning, Ministry of Environment and Forestry, Republic of Indonesia. Jl. Juanda No. 15, Bogor, 16112, West Java, Indonesia

<sup>3</sup>Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry and Environment, Institut Pertanian Bogor. Jl. Ulin-Lingkar Akademik, Dramaga, Bogor 16680, West Java, Indonesia

<sup>4</sup>Research Center for Biosystematics and Evolution, National Research and Innovation Agency (BRIN). Jl. Raya Jakarta-Bogor Km.46 Cibinong, Bogor 16911, West Java, Indonesia

Manuscript received: 27 July 2024. Revision accepted: 9 October 2024.

**Abstract.** Munawir A, Mardiasuti A, Masy'ud B, Prawiradilaga DM. 2024. Rehabilitation criteria and indicators for the successful release of Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924). *Biodiversitas* 25: 3491-3499. The Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924) is an endangered bird of prey that is native to Java Island and is protected by law. In order to save the species, rehabilitation programs are crucial for increasing its population in the wild. The current research aimed to establish criteria and indicators for rehabilitating Javan hawk-eagles and improving their chances of a successful release. Data were collected from literature review, interviews, and field observation. Collected data were scored based on a Likert scale and weighted on selected criteria and indicators, then described qualitatively. The research resulted in the identification of 34 criteria and 152 indicators. There were several rehabilitation stages observed in this research: 1) acceptance stage with 10 criteria and 30 indicators; 2) isolation stage with as many as six criteria and 18 indicators; 3) treatment stage with as many as four criteria and 12 indicators; 4) pre-training stage with as many as five criteria and 15 indicators; 5) training stage with five criteria and 65 indicators, and 6) habituation stage with four criteria and 15 indicators. The testing of 12 Javan hawk-eagle individuals at the Javan Hawk-eagle Sanctuary Center (JHESC), along with the developed criteria and indicators, could be feasible for rehabilitation standards to release Javan hawk-eagles successfully. According to the decision tree, nine out of the 12 individuals went through four stages, one went through three stages, and two went through two stages. In summary, the criteria and indicators have increased potential numbers and accelerated the rehabilitation process for the success of Javan hawk-eagle release.

**Keywords:** Conservation, ecology, Javan hawk-eagle, raptor, rehabilitation program

## INTRODUCTION

Wildlife habitat fragmentation persists due to development activities, infrastructure, and land use changes resulting from spatial planning policy changes in various countries (Martinuzzi et al. 2015; Liu et al. 2016; Zhang et al. 2022; Yue et al. 2023). Habitat fragmentation can threaten species diversity, biodiversity, and species distribution (Wang 2020; de Lima Filho et al. 2021; Kuipers et al. 2021) and has led to the extinction of species globally, including in Java, Indonesia (Mullu 2016; Gunawan et al. 2024). The Javan hawk-eagle (*Nisaetus bartelsi* Stresemann, 1924) is a protected species found on Java Island and is of great importance for conservation efforts worldwide. Endemic to Java Island, it inhabits forests ranging from lowland to highland, up to 3000 meters above sea level (Eaton et al. 2016; Eaton et al. 2021). The Javan hawk-eagle is currently under threat of extinction and is listed as endangered/threatened on the red list of the International Union for Conservation of Nature (IUCN) (BirdLife International 2017). The estimated total population size of Javan hawk-eagles was around 511 pairs in 2023 (Syartinilia et al. 2023). Furthermore, this species is also designated as

one of 25 conservation priority species in Indonesia.

Habitat destruction, poaching, and illegal trade pose a severe threat to the survival of these species (Gunawan et al. 2016; Nurfatimah et al. 2017; Adhikari et al. 2022; Iskandar et al. 2022; Syartinilia et al. 2024). The trade of raptor species in January-December 2015 was very high, with 2,471 individuals of 21 species recorded as birds, including 127 individuals of Javan hawk-eagles (Gunawan et al. 2017). Based on the analysis of satellite imagery on Java Island, deforestation in 2009-2013 increased and reached 326,953.09 ha or 32.64% of the total area of natural forest cover (Ministry of Environment and Forestry 2020). It resulted in the fragmentation of the Javan hawk-eagle habitat. To prevent the decline and even extinction of the Javan hawk-eagle, the Indonesian government has carried out various conservation programs, both in its natural habitat (in-situ) and outside its natural habitat (ex-situ). Ex-situ conservation programs that have been carried out are the rehabilitation and release of Javan hawk-eagle (Mount Halimun Salak National Park 2019). The release of Javan hawk-eagles is divided into three stages: pre-release, release, and post-release (Prawiradilaga 2018).

As an ex-situ sanctuary for Javan hawk-eagles, the Javan Hawk-eagle Sanctuary Center (JHESC) has been established to facilitate the release program. The center is dedicated to rehabilitating and releasing Javan hawk-eagles in Indonesia and has been managed by Gunung Halimun Salak National Park since 2015. From 2016-2023, JHESC received 95 eagles, 23 of which were Javan hawk-eagle, for rehabilitation and release. All the eagles were handed over by the Natural Resources Conservation Agency (*Balai Konservasi Sumber Daya Alam*) of East Java, Central Java, Yogyakarta, DKI Jakarta, and West Java. Some of the eagles were surrendered by community who previously kept them as pets, while others were confiscated by the Natural Resources Conservation Center and then handed over to JHESC so that they can be rehabilitated before being released into the wild. From the beginning until 2020, JHESC did not have or use a standard for rehabilitating and releasing Javan hawk-eagles (Javan Hawk-eagle Sanctuary Center 2023). The treatments were still conducted using a 'trial and error' process based on various experiences and knowledge of JHESC officers. This was because no information on sources and guidelines was available. However, assessing the successful rehabilitation of wildlife and their suitability for release into natural habitats requires the minimum standards for animal rehabilitation (Miller 2012; Englefield et al. 2019; Willette et al. 2023).

In order to optimize the success of the Javan hawk-eagle release, rehabilitation and release guidelines must be established. The development of national standards for the rehabilitation and release of the Javan hawk-eagle has been identified as a priority in the Conservation Strategy and Action Plan (CSAP) document for 2013-2022. Hence, establishing specific criteria and indicators is necessary to evaluate the effectiveness of Javan hawk-eagle rehabilitation and release programs in Indonesia. Hopefully, this will support the success of rehabilitation programs in the future and increase eagle populations in the wild (International

Union for Conservation of Nature and Natural Resources 2013).

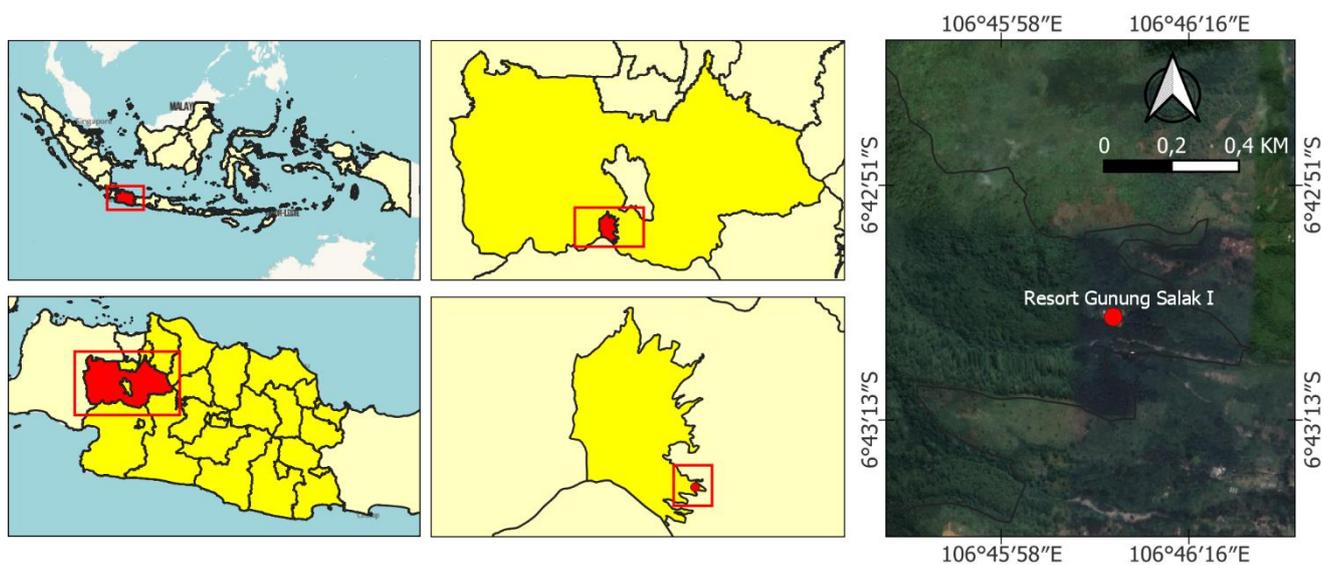
## MATERIALS AND METHODS

### Study area

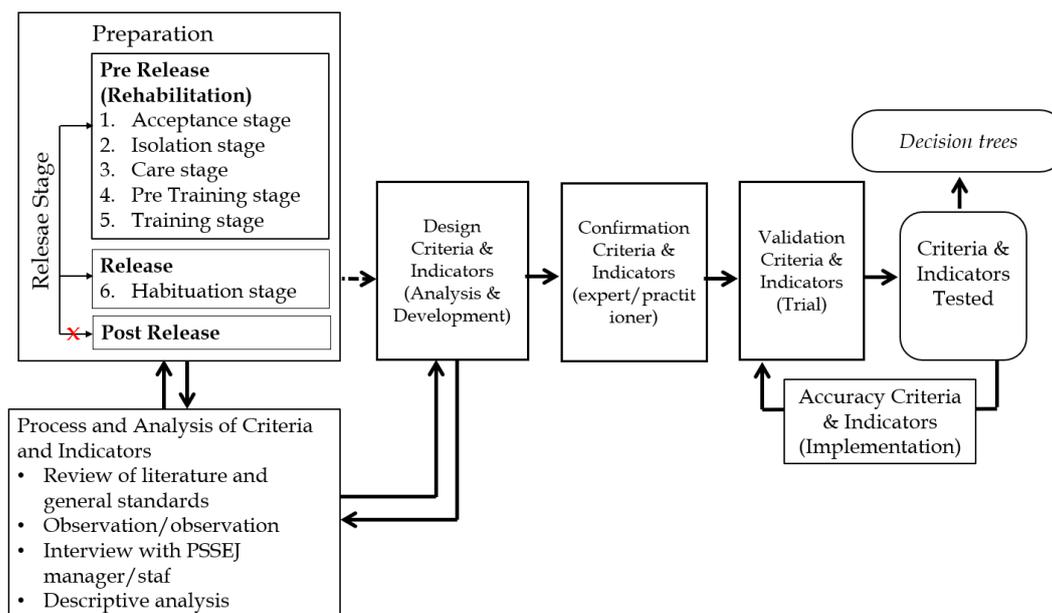
The research was conducted at the Javan Hawk-eagle Sanctuary Center (JHESC)(6°43'3.43"S 106°46'8.81"E), Gunung Halimun Salak National Park (GHSNP) area in Bogor District, West Java Province, Indonesia (Figure 1). JHESC is a specialized institution managed by the government through the Gunung Halimun Salak National Park. It was designed to rehabilitate and release eagles and raptors back to nature, particularly the Javan hawk-eagle. Furthermore, JHESC is dedicated to providing an educational platform for the conservation of raptors, including limited ecotourism, research, and scientific development. Data collection, standardization, standard testing, and reporting were conducted from April 2021 to March 2023.

### Data collection

Data were collected using mixed methods, including a literature review, interviews, and field observations at each stage of rehabilitation and release of Javan hawk-eagle (Noga et al. 2018). This study collected data on all the criteria and indicators of success at each stage of rehabilitation and release, with a particular focus on the health and behavioral aspects (Cope et al. 2022). The compilation of Rehabilitation Criteria and Indicators for the Successful Release of Javan Hawk-eagle (RCISRJHE) used a research model developed from the Borg and Gall model (Maydiantoro 2021). The stages included: 1) preparation, 2) process and analysis, 3) drafting, 4) design confirmation by experts and practitioners, 5) validation through pilot testing, 6) tested tools, and 7) decision tree analysis (Figure 2).



**Figure 1.** Map of the research area of Javan Hawk-eagle Sanctuary Center in Resort Gunung Salak I, Sukabumi District, West Java, Indonesia



**Figure 2.** A research framework for developing rehabilitation criteria and indicators for successful Javan hawk-eagle release

**Table 1.** Description of the assessment of criteria and indicators of rehabilitation and release of Javan hawk-eagle

Criteria and indicators
• Acceptance stage of animals: Physical (beak, eyes, feet, claws, wings, tail), disease (avian flu, newcastle disease, bumblefoot), behavior (wildness, feeding, and flight)
• Isolation stage: Potential infectious diseases (avian flu, newcastle disease (tetelo), bumblefoot)
• Treatment stage: Physical (beak, eyes, feet, claws, wings, tail)
• Pre-training stage: Behavior (wildness towards humans, how to hunt, eat, fly, and preen themselves)
• Training stage: Aggressiveness and wildness, hunting, eating prey, flying, preening and cleaning (beak, claws, dryingitself)
• Habituation stage: Stress levels (dehydration, presence of other individuals or eagle species, human presence), flight, hunting, and feeding

The initial stage of the research involved preparing and designing RCISRJHE. This was accomplished by examining the program and empirical findings from the implementation of Javan hawk-eagle rehabilitation and release at JHESC and by studying references related to standards or general criteria for the rehabilitation and release of Javan hawk-eagle. The current study aimed to ensure that the structure of the RCISRJH was comprehensive and reflected the physical condition, behavior, and health of the Javan hawk-eagle (Miller 2012). Using purposive sampling methods (Etikan et al. 2016), data were gathered through field observations and interviews with JHESC managers, including one medical staff member, five animal keepers, and four technical and administrative staff members.

A confirmation phase was conducted to review the RCISRJHE draft. The experts who reviewed the draft are

two academics from Institut Pertanian Bogor, two bureaucrats, namely the Director General of Natural Resources Conservation and Ecotourism and Director of Biodiversity, Genetic and Species Conservation, Ministry of Environment and Forestry, two practitioners from Kamojang Eagle Conservation Center and *Konservasi Elang Indonesia* Foundation, and a researcher from National Research and Innovation Agency (BRIN) competent in wildlife rehabilitation and release. The meeting with academics from Institut Pertanian Bogor and eagle conservation practitioners discussed the important stages of rehabilitation and the essential criteria and indicators to consider. Then, the meeting with bureaucrats discussed the importance of wildlife rehabilitation centers, especially animal rehabilitation and release guidelines, and also discussed the achievements of the Javan hawk-eagle's Conservation Action Plan Strategy document. Discussions with researchers related to wildlife behaviors that are of concern in assessing the suitability of rehabilitated animals for release. From the results of these meetings, they essentially assessed the appropriateness of the criteria and indicators and evaluated the weights and values assigned to each criterion and indicator (Table 1).

Trials were carried out on the Criteria and Indicators (CI) instrument with 12 eagles at RCISRJH (Figure 3). This comprehensive test aimed to determine whether the CI instrument can be used to assess the success of individual Javanese eagle rehabilitation and reintroduction to their natural habitat. The reliability of the RCISRJH instrument as a measurement tool has been demonstrated, provided that all Javan hawk-eagle individuals in the study were successfully assessed concerning the appropriate actions taken in each test. The criteria and indicators, from the acceptance stage to the habituation stage for release, were assessed on 12 Javan hawk-eagles being brought to the JHESC.



**Figure 3.** Performance of 12 Javan hawk-eagles as trial objects in this study

### Data analysis

Quantitative-descriptive analysis was used to analyze data at each stage of rehabilitation and release, supported by tables, graphs, and images. Additionally, quantitative analysis was conducted by assigning scores based on expert judgment from competent practitioners and experts. All indicators were rated on a likert scale from 1 to 3 or 1 to 5. The score ranges from 1, indicating 'very low', to 5, indicating 'very feasible' (Hochwald et al. 2023).

## RESULTS AND DISCUSSION

### Criteria and indicators of rehabilitation

#### Acceptance stage

The acceptance stage is a crucial phase in which the rehabilitation center manager determines whether the Javan hawk-eagle is suitable for rehabilitation. The primary focus at this stage is to assess the animal's medical condition. Therefore, to achieve this, ten criteria with 30 indicators have been developed. Each criterion carried different weight, including the condition and function of body parts, such as eyes, feet, claws, beak, and wings (30%); behavior in the form of wildness, aggressiveness, food type, feeding, flying, and deviant/stereotyped behavior (30%); and health conditions such as the presence or absence of disease and injury (40%), with each indicator scored from 1-3. Based on the assessment criteria and indicators, a conclusion can be drawn: 1) If the total indicator score is 30, release the animal directly; 2) If the total indicator score is less than 30, accept the animal for rehabilitation. Furthermore, notes should be included: a) If the bird was infected with an infectious disease, it was necessary to isolate it initially; b) If there was

an injury on the body, it was vital to begin treatment immediately; c) If there was no disease or injury, the bird can proceed directly to the pre-training stage; and 3) the animals should be accepted and placed in the education cage only if their vital organs (eyes, legs, wings, and beak) were functioning correctly.

The Javan hawk-eagle relies on vital organs such as its eyes, feet, claws, beak, and wings to see, fly, hunt, and eat prey to survive after being released. According to Adu et al. (2023), the Javan hawk-eagle also has essential body parts, such as sharp eyes and strong foot grips, used for hunting. Additionally, the beak of the Javan hawk-eagle serves as an ingestion organ for feeding activities. Raptors typically use their claws to grip prey and their beak to tear it apart (Tsang et al. 2019; Tsang and McDonald 2019). During rehabilitation, the wild character of eagles is also observed. For instance, eagles in captivity for extended periods exhibit less frequent flight and aggression than wild ones (Sawitri and Takandjandji 2010).

#### Isolation stage

The isolation stage is initiated for Javan hawk-eagles, which got positive responses for infectious diseases after being tested. At this stage, there were six criteria with 18 indicators. Each criterion has various weights. The assessment criteria identified six diseases in poultry, each with a score of 1-3: (i) Avian Influenza Virus (AIV) (25%), (ii) Newcastle Disease Virus (NDV) (25%), (iii) Infectious Bronchitis Virus (IBV) (10%), (iv) Helminth parasite infection disease (10%), (v) Coccidiosis/giardiasis/amoeba protozoa infection (10%), and (vi) Bumblefoot (20%). Based on the assessment of criteria and indicators, it could be possible: (i) The wildlife to proceed to the pre-training

stage if the total indicator score of 18 (animals were no longer infected with infectious diseases and were in such a healthy condition); (ii) Continue isolation if the total indicator score <18 (animals were no longer infected with infectious diseases, but they have not been recovered); and euthanasia was recommended if the total indicator score was <18 (animals were still infected with infectious diseases and the health condition of the animal was deteriorating, and threatened staff and other eagles).

Information regarding infected animals due to disease was obtained through laboratory tests at JHESC. Ensuring that Javan hawk-eagles were free from infectious diseases was crucial to prevent transmission to other eagles or nurses at JHESC. The health check for Javan hawk-eagles included testing for zoonosis, an infectious disease in wildlife (González-Barrio 2022). The Javan hawk-eagles could also be a potential carrier of zoonoses in its natural habitat (Hugh-Jones et al. 1995).

#### *Treatment stage*

The Javan hawk-eagles entering the treatment phase are not well due to injuries or wounds. The criteria and indicators in this treatment phase mainly focus on the physical condition by assessing the health and function of the eyes, wings, feet (including legs, toes, and claws), and beaks. At this stage, there were four criteria with 12 indicators. Each criterion carried equal weight, namely: (i) Eye health and functionality (25%); (ii) Wing health and functionality (25%); (iii) Toes health and functionality, including legs, toes, and claws/feet (25%); and (iv) Beak health and functionality (25%). Each indicator was scored from 1 to 3. The decisions made were: (i) If the total indicator score was 12, move the animal to the pre-training phase; (ii) If the total indicator score was less than 12 but there were some improvements in health, continue treatment; (iii) If the total indicator score remained below 12 but the animal was in good health with physical organ dysfunction, stop the treatment phase and move the animal to the training cage. The Javan hawk-eagle relied heavily on the health and function of its eyes, wings, feet (legs, toes, and claws), and beak to carry out its activities, especially hunting and feeding. Birds of prey typically use their claws to grasp prey and their beaks to tear it apart (McClure et al. 2019; Subagja 2021). After catching its prey, the eagle brings it over to a perching tree and plucks its feathers using its beak (Ilmi et al. 2022; Dhanial et al. 2023).

#### *Pre-training stage*

The pre-training stage is the first step to training the Javan hawk-eagle's wild or natural behavior. The Javan hawk-eagles entering this stage must be in perfect physical condition, healthy without any injuries, and disease-free. The criteria and indicators developed at this stage are focused on behavioral assessment. At this stage, there were five criteria with 15 indicators. Each criterion has a different weight, such as: (i) Wildness towards human presence (25%); (ii) Hunting behavior (25%); (iii) Prey tearing and swallowing behavior (25%); (iv) Flight ability (15%); and (v) Preening behavior (cleaning feathers, plucking feathers, sharpening beak, claws) (10%), and each indicator has a

value of 1-3 according to the likert scale. Based on the assessment of criteria and indicators, it was decided: (i) Proceed the animal to the training phase if the total indicator score was 15; (ii) Continue the pre-training stage if the total score of indicators was <15 after undergoing pre-training  $\leq 45$  days (1.5 months); (iii) Discontinue the pre-training stage if the total score of indicators was <15 after undergoing pre-training for a maximum of 60 days (2 months).

The pre-training stage can stimulate the Javan hawk-eagle's behavior to develop its instincts and wild nature. In this context, wilderness is defined as protecting one's territory from disturbances (human presence) or other species. The territory that the Javan hawk-eagle defends is the area that is vital for its life, such as the presence of nests (Utami 2002).

#### *Training stage*

The training stage is essential for restoring the Javan hawk-eagle's natural behavior. Enabling the Javan hawk-eagle to adapt, survive, and reproduce in its natural habitat is essential for its successful release. There were five criteria with 65 indicators during this stage. Each criterion carried a different weight. The criteria for assessing the subject's behavior included aggressiveness and wildness (20%), hunting prey (25%), eating (15%), flying (30%), and self-care/preening (10%), each rated on a scale of 1-5. Decisions can be made based on the assessment results: (i) The readiness for release of the Javan hawk-eagle was determined by a total score multiplied by weight of  $\geq 400$  at the time of observation; (ii) If the total value remained <400 within a maximum period of 7 months in the training cage, the Javan hawk-eagle was deemed not ready for release; (iii) If the total score was <400 and the Javan hawk-eagle had been in training for more than seven months, it was not worth releasing.

Moreover, the primary focus at this stage is the Javan hawk-eagles' flying ability. Flight is a skill that requires training as it is essential for many natural activities. It serves various purposes, such as observing prey, attracting mates, and teaching offspring. A raptor's hunting success relies heavily on its air maneuverability (Mills et al. 2019; Ulumiyah et al. 2019). The Javan hawk-eagle glides, soars, undulates, and haves and carries materials for the nest in its natural habitat (Luthfi et al. 2020).

The Javan hawk-eagle's ability to hunt and bring prey to a perch for consumption is also assessed during the training stage. When hunting, Javan hawk-eagles soar above the forest canopy or open landscape in search of prey movements (Prawiradilaga 2006). After capturing its prey, the Javan hawk-eagle consumes it while perching. Research on the eating behavior of the Javan hawk-eagle indicates that they always carry their prey to perches (Utami 2002; Yuliamalia et al. 2021). Javan hawk-eagles employ three techniques for handling prey: plucking hair, tearing, and swallowing. Furthermore, training activities aim to stimulate their natural aggression and wildness and promote self-care and preening. Proper self-care training is crucial for Javan hawk-eagles to maintain their physical health after being released into the wild. This fragment describes various self-care activities that birds engage in, such as cleaning

themselves, plucking dead or damaged feathers, keeping their bodies wet, and sharpening their beaks and claws on the perch. Preening, which involves cleaning the body and sunbathing, is a vital aspect of self-care behavior (Jones and Heidenreich 2021).

#### *Habituation stage*

Habituation is a method employed to acclimate the Javan hawk-eagle to its natural habitat before its release. This is an essential step in the release process, as it enables the eagle to adjust to its new environment and rest after traveling from JHESC to the release location. During this stage, four criteria with 12 indicators were established. Each criterion was assigned in different weight: (i) Dehydration (30%); (ii) Response to the presence of other eagles around the cage (20%); (iii) Response to the presence of humans around the cage (20%); (iv) Hunting and eating the provided prey (30%).

Each indicator was rated on a scale of 1-3 using the likert scale. Based on the assessment of criteria and indicators, a decision can be made at this stage to: (i) Either release the Javan hawk-eagle if it scored 12 or above; (ii) Retrain it if it scored less than 12 after five days in the habituation cage.

During habituation, the Javan hawk-eagle's condition is continuously monitored for signs of dehydration and stress caused by other eagles and humans around the cage and its response to the prey provided. The food given to the eagles at JHESC is sourced from the release location and may be alive. It is recommended that animals be provided with food from the release location upon release (Hall 2005). The presence of humans can disrupt the success of the Javanese eagle's habituation process close to the habituation cage. Therefore, it is of utmost importance that we, as the audience, understand and respect the need to limit our presence at this stage, ensuring the eagles' successful habituation.

#### **Trial of criteria and indicator assessment**

The criteria and indicators developed above were tested on 12 Javan hawk-eagle individuals from the acceptance to habituation stages (Table 2).

The trial test results at the acceptance stage revealed that Javan hawk-eagles namely Parama, Rahman, Pesona, Lawa, Ujang, Ragil, Salaka, Yumna, and Yuri, were accepted for rehabilitation and entered the pre-training stage. Their indicator values ranged from 22-29. Iskandar, Feri, and Arsyhan were also accepted for rehabilitation but required treatment for wing injuries prior to rehabilitation. Based on laboratory examinations, the current study found that no Javan hawk-eagles were positive for infectious diseases. Therefore, none entered the isolation phase.

Only Iskandar could continue to the pre-training stage after undergoing treatment, while Feri and Arsyhan could not continue due to permanent wing defects. The pre-training stage was reserved for healthy eagles free from injury or disease. The two eagles that cannot proceed to the pre-training stage will be placed in the education cage for education and research purposes. Following the assessment of criteria and indicators during the pre-training stage, it was determined that all ten Javan hawk-eagles that entered the stage with an indicator value of 15 would proceed to the training stage.

During the training stage, the trial test results assessing criteria and indicators revealed that nine out of ten Javan hawk-eagles (90%) had a total score above 400 and were deemed ready for release. During the habituation stage, all Javan hawk-eagles remained hydrated and exhibited active flying behavior, a positive sign of their readiness for release. They are not intimidated by other eagles flying around the cage and hunting the live prey provided and do not show fear of humans around the cage. Based on assessing the criteria and indicators for the habituation stage, it was decided to release nine Javan hawk-eagle individuals into their natural habitat. Parama and Iskandar were released with a Solar GPS-Argos device installed to monitor their post-release adaptation abilities.

**Table 2.** The trial results for assessing criteria and indicators at all stages of rehabilitation for Javan hawk-eagle release. There was no

No.	Individual Name	Acceptance Stage		Treatment Stage		Pre-training Stage		Training Stage		Habituation Stage	
		Value C&I	Decision	Value C&I	Decision	Value C&I	Decision	Value C&I	Decision	Value C&I	Decision
1	Parama ♂	29	pre-training	→	→	15	training	462	ready for release	12	release
2	Rahman ♂	28	pre-training	→	→	15	training	423	ready for release	12	release
3	Pesona ♂	23	pre-training	→	→	15	training	440	ready for release	12	release
4	Lawa ♂	25	pre-training	→	→	15	training	427	ready for release	12	release
5	Ujang ♂	24	pre-training	→	→	15	training	422	ready for release	12	release
6	Ragil ♂	28	pre-training	→	→	15	training	430	ready for release	12	release
7	Salaka ♂	29	pre-training	→	→	15	training	419	ready for release	12	release
8	Yumna ♂	22	pre-training	→	→	15	training	438	ready for release	12	release
9	Yuri ♀	22	pre-training	→	→	15	training	355	not ready for release	-	-
10	Iskandar ♂	28	care	12	pre-training	15	training	445	ready for release	12	release
11	Feri ♂	18	care	10	rehabilitation	rehabilitation was not continued due to permanent disability of the wing					
12	Arsyan ♀	18	care	10	rehabilitation	rehabilitation was not continued due to permanent disability of the wing					

Note: Javan hawk-eagle in the isolation stage

**Rehabilitation decision tree for Javan hawk-eagle release**

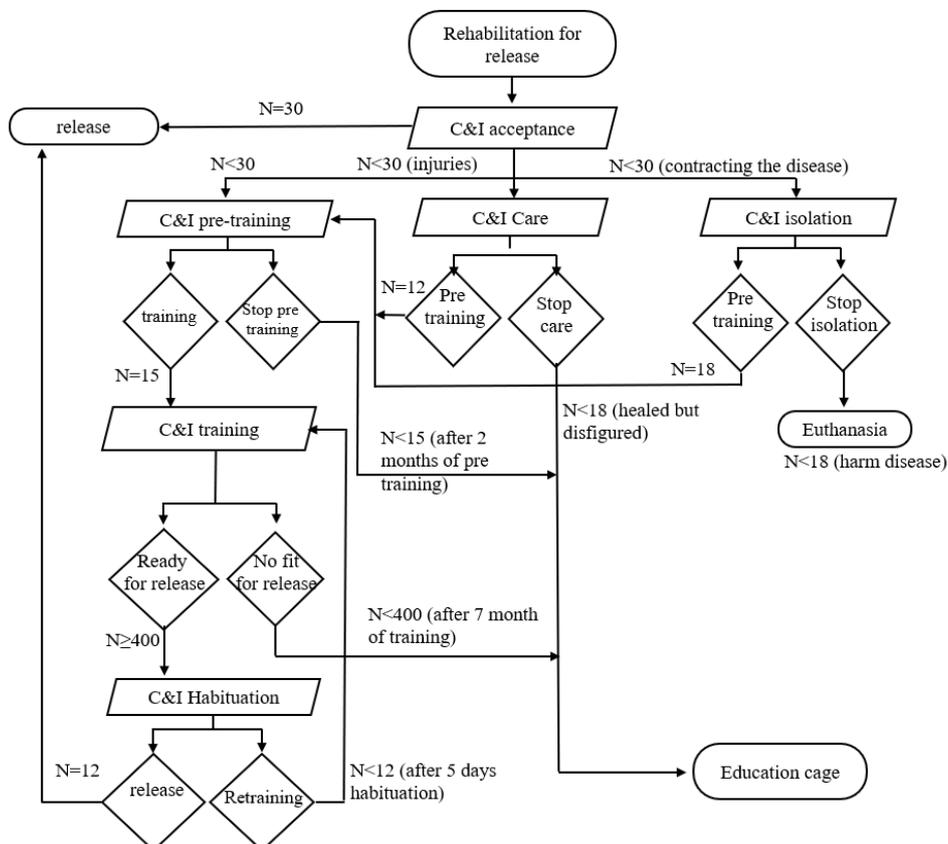
The decision tree was created based on the sequence observed during the rehabilitation and release of Javan hawk-eagles at JHESC (Figure 4). The rehabilitation and release process assessment started with completing an intake form. During the acceptance stage, there were five decision options available: (i) The process for rehabilitating a Javan hawk-eagle involved a pre-training stage; (ii) Releasing a Javan hawk-eagle if the criteria and indicators for determining its behavior were scored three (good) without exception; (iii) Treatment of wounds or physical injuries; (iv) Isolation is if it becomes ill due to infection with viruses, bacteria, and protozoa listed in the isolation criteria and indicators; (v) Euthanasia may be considered if the Javan hawk-eagle's eyes met specific criteria and indicators for physical condition, such as a function of less than 20%.

Additionally, if the eagle's beak was broken, cracked, abnormally short, or does not function properly for hunting prey, euthanasia may also be considered. The Javan hawk-eagle will receive medical assistance only if the criteria and indicators for animal care are met. If these conditions are satisfied, the Javan eagle can proceed to the pre-training stage. However, if the Javan hawk-eagle was disabled due to an injury or wound; it was recommended to be sent for education at JHESC or used for research and educational purposes. Javan hawk-eagles that met the isolation criteria and indicators due to contracting a disease must be isolated. If the eagle cannot be cured with an overall score of one, then the eagle must be euthanized. When the Javan hawk-

eagle can be cured and not isolated, the eagle will enter the pre-training stage.

Only Javan hawk-eagles with an overall score of three can enter the training stage after meeting the pre-training criteria and indicators. However, if the Javan hawk-eagle lasts two months with an additional day of approximately 15 days, the criteria and indicator values remained at one (bad grade). This Javan hawk-eagle should be considered for placement in an educational cage for conservation purposes. The pre-training stage's deadline was based on trial results and resource considerations in the rehabilitation process.

Only Javan hawk-eagles that have passed the pre-training stage with an 'A' grade were eligible for the training stage. During the training stage assessment, there were three decisions to be made: (i) Javan hawk-eagles were deemed ready for release if their total behavioral score fell within the range of 400-500, provided that their flight behavior was not less than 150; (ii) If the total behavioral score of a Javan hawk-eagle was below 400 and there was still a chance of improving its behavior based on monitoring, then it was not ready for release into the wild; and (iii) If the total animal behavior score was below 250 after five months of training or remained below 400 after five months of training and an additional two months of further training, the Javan hawk-eagle will not be released into the wild. This Javan hawk-eagle should be placed in the educational enclosure at JHESC or conservation institutions for ex-situ conservation purposes and at research institutions or universities for research purposes.



**Figure 4.** Decision tree of rehabilitation for Javan hawk-eagle release

Javan hawk-eagles that were ready for release underwent a habituation stage. The eagles were assessed based on specific criteria and indicators during this stage. If the eagle scores three (good), it will be released. However, if the eagle spent more than seven days in the habituation cage and its condition was not yet suitable for release, it will return to training; the decision tree for rehabilitating and releasing Javan hawk-eagles involved three possible outcomes. The initial decision was to release the Javan hawk-eagle. The subsequent decision was to relocate the Javan hawk-eagle to an educational enclosure, conservation institution, or university research facility. The final decision was to euthanize the Javan hawk-eagle using appropriate procedures.

The research findings, based on observations of 12 individuals, indicated that not all individuals underwent the same stages. Nine individuals went through four stages, one through three and two through two stages. No individuals were released into the wild immediately, and none entered the isolation stage. Three individuals entered the treatment stage. The different treatment was due to the varying initial conditions when the eagles were received at JHESC.

#### Implications of research on the rehabilitation and release management of Javan hawk-eagle

The criteria and indicators, developed in collaboration with animal keepers, have proven to facilitate the handling of Javan hawk-eagles upon their arrival at the rehabilitation center. The assessment results of these criteria and indicators served as a guide or benchmark for compiling the life history of each Javan hawk-eagle during the rehabilitation and release process. Using criteria and indicators in this research made it easier for animal keepers to provide assessments at each rehabilitation stage. The results were proven: in 2021, JHESC released 14 eagles, four of which were Javan hawk-eagles, three Crested serpent-eagles (*Spilornis cheela* (Latham, 1790)), six Changeable hawk-eagles (*Nisaetus cirrhatus* (Gmelin, 1788)), and one Crested goshawk (*Accipiter trivirgatus* Temminck, 1824), and in 2022, JHESC released 22, six of which were Javan hawk-eagles, seven Changeable hawk-eagles, six Crested serpent-eagles, four Black kites (*Milvus migrans* (Boddaert, 1783)). In fact, in the previous year, in 2019, JHESC only legalized one eagle, namely the Changeable hawk-eagle; in 2020, it only released four eagles, two Changeable hawk-eagles, one Crested goshawk, and one Crested serpent-eagle. The criteria and indicators have several implications: (i) They can increase the potential number of eagles that can be released from JHESC; (ii) They can enhance the Human Resources (HR) competency that manages the Javan hawk-eagle rehabilitation center; (iii) They can increase the efficiency of rehabilitation and release the budget for Javan hawk-eagles.

In conclusion, the rehabilitation stage of the Javan hawk-eagle in this study was divided into six stages, with several criteria and indicators at each stage to assess the progress of each eagle and whether it remained in the same stage of rehabilitation or progressed to another stage. The success criteria and indicators of Javan hawk-eagle rehabilitation were evaluated on 12 eagles. The trial results indicated that

9 of the 12 eagles were prepared for release and had been successfully released into their natural habitat. Consequently, the criteria and indicators that have been developed can be implemented as a management standard for the rehabilitation and release of Javan hawk-eagles. Furthermore, the decision tree was employed in the rehabilitation and release of Javan hawk-eagles to facilitate the deconstruction of intricate decision-making processes into simpler ones. This research had numerous implications for Javan hawk-eagles' rehabilitation and release management, including the potential to increase the number of released eagles, human resource competence, and the efficiency of rehabilitation and release budgets. The results of this research also have the potential to serve as a guideline or benchmark for national standards for the rehabilitation and release of Javan hawk-eagles and other raptor species (birds of prey) in the future.

#### ACKNOWLEDGEMENTS

The authors would like to thank the Head of Gunung Halimun Salak National Park, West Java-Banten, Indonesia for permitting research at Javan Hawk-eagle Sanctuary Center (JHESC) through Permit No. 13A/P/TNGHS/4/2022, dated 25 April 2022. They would also like to thank the medical team, keepers, and technical staff at JHESC for helping to conduct this research.

#### REFERENCES

- Adhikari B, Bhandari S, Baral K, Lamichhane S, Subedi SC. 2022. Raptors at risk: Attributes of mortality within an anthropogenic landscape in the Mid-Hills region of Nepal. *Glob Ecol Conserv* 38: e02258. DOI: 10.1016/j.gecco.2022.e02258.
- Adu SJ, Arief H, Sunarminto T. 2023. Habitat and behavior of Javan hawk-eagle (*Nisaetus bartelsi*) in SPTN 2 Majelengka Gunung Ciremai National Park, West Java. *J Nat Resour Environm Manag* 13 (2): 332-340. DOI: 10.29244/jpsl.13.2.332-340.
- BirdLife International. 2017. *Nisaetus bartelsi* (amended version of 2016 assessment). The IUCN Red List Threat Species 2017: eT22696165A110050373. DOI: 10.2305/IUCN.UK.2017-1.RLTS.T22696165A110050373.en. [Accessed on 10 July 2024].
- Cope HR, McArthur C, Dickman CR, Newsome TM, Gray R, Herbert CA. 2022. A systematic review of factors affecting wildlife survival during rehabilitation and release. *PLoS One* 17 (3): e0265514. DOI: 10.1371/journal.pone.0265514.
- de Lima Filho JA, Vieira RJAG, de Souza CAM, Ferreira FF, de Oliveira VM. 2021. Effects of habitat fragmentation on biodiversity patterns of ecosystems with resource competition. *Physica A: Stat Mechanic Appl* 564: 125497. DOI: 10.1016/j.physa.2020.125497.
- Dhanira R, Istiana R, Zufitrianto H, Supratman L. 2023. Diurnal activity of crested serpent-eagle (*Spilornis cheela*) in Pusat Suaka Elang Jawa. *Media Konservasi* 28 (2): 201-209. DOI: 10.29244/medkon.28.2.201-209.
- Eaton J, van Balen B, Brickley NW, Rheindt F. 2021. *Birds of the Indonesian Archipelago: Greater Sundas and Wallacea*. Ed ke-2. Lynx Edicions, Barcelona.
- Eaton J, van Balen B, Brickley NW, Rheindt FE. 2016. *Birds of the Indonesian Archipelago: Greater Sundas and Wallacea*. Lynx Edicions, Barcelona.
- Englefield B, Blackman SA, Starling M, McGreevy PD. 2019. A review of Australian animal welfare legislation, regulation, codes of practice, and policy, and their influence on stakeholders caring for wildlife and the animals for whom they care. *Animals* 9 (6): 335. DOI: 10.3390/ani9060335.

- Etikan I, Musa SA, Alkassim RS. 2016. Comparison of convenience sampling and purposive sampling. *Am J Theor Appl Stat* 5 (1): 1-4. DOI: 10.11648/j.ajtas.20160501.11.
- González-Barrio D. 2022. Zoonoses and wildlife: One health approach. *Animals (Basel)* 12 (4): 480. DOI: 10.3390/ani12040480.
- Gunawan H, Setyawati T, Atmoko T, Subarudi, Kwatrina RT, Yeny I, Yuwati TW, Effendy R, Abdullah L, Mukhlisi, Lastini T, Arini DID, Sari UK, Sitepu BS, Pattiselano F, Kuswanda W. 2024. A review of forest fragmentation in Indonesia under the DPSIR framework for biodiversity conservation strategies. *Glob Ecol Conserv* 51: e02918. DOI: 10.1016/j.gecco.2024.e02918.
- Gunawan N, Fauziah R, Zulham D, Djamaludin, Pramono H, Yuniar A. 2016. New homes on misty mountains: Javan hawk-eagle *Nisaetus bartelsi* and changeable hawk-eagle *Nisaetus cirrhatus* nesting in Gunung Halimun Salak National Park, West Java, Indonesia. *Podoces* 11 (1): 1-6.
- Gunawan Z, Pramono H, Djamaludin, Yuniar A, Hardina K, Mulyati S, Kuswandono, Kristiana I. 2017. Release of confiscated raptors in Indonesia by Suaka Elang (Raptor Sanctuary): Protocols and progress to date. *BirdingASIA* 27: 88-93.
- Hall E. 2005. Release Consideration for Rehabilitated Wildlife. Australian Wildlife Rehabilitation Conference, Queensland.
- Hochwald IH, Green G, Sela Y, Radomyslsky Z, Nissanholtz-Gannot R, Hochwald O. 2023. Converting qualitative data into quantitative values using a matched mixed-methods design: A new methodological approach. *J Adv Nursing* 79 (11): 4398-4410. DOI: 10.1111/jan.15649.
- Hugh-Jones M, Hubbert W, Hagstad HV. 1995. Zoonoses: Recognition, Control, and Prevention. Iowa State University Press, Iowa.
- Ilmi AR, Elfidasari D, Mercusiana S. 2022. Aktivitas harian elang jawa (*Nisaetus bartelsi*) rehabilitasi di Pusat Suaka Satwa Elang Jawa. *J Bios Logos* 12 (2): 80-86. DOI: 10.35799/jbl.v12i2.40730. [Indonesian]
- International Union for Conservation of Nature and Natural Resources. 2013. Guidelines for Reintroductions and Other Conservation Translocations version 1.0. IUCN Species Survival Commission, Gland.
- Iskandar RRD, Elfidasari D, Prawiradilaga DM. 2022. Identification of spatial data and ecology of Javan hawk-eagle's nest (*Nisaetus bartelsi*) in the Kondang Merak Coastal, South Malang, East Java, Indonesia. *Biodiversitas* 23 (7): 3419-3428. DOI: 10.13057/biodiv/d230714.
- Javan Hawk-eagle Sanctuary Center. 2023. Management Report of Javan Hawk Sanctuary Center 2018-2023 Period. Javan Hawk-eagle Sanctuary Center, Bogor. [Indonesian]
- Jones MP, Heidenreich B. 2021. Behavior of birds of prey in managed care. *Vet Clin North Am Exot Anim Pract* 24 (1): 153-174. DOI: 10.1016/j.cvex.2020.09.007.
- Kuipers KJJ, Hilbers JP, Garcia-Ulloa J, Graae BJ, May R, Verones F, Huijbregts MAJ, Schipper AM. 2021. Habitat fragmentation amplifies threats from habitat loss to mammal diversity across the world's terrestrial ecoregions. *One Earth* 4 (10): 1505-1513. DOI: 10.1016/j.oneear.2021.09.005.
- Liu Z, He C, Wu J. 2016. The relationship between habitat loss and fragmentation during urbanization: An empirical evaluation from 16 world cities. *PLoS One* 11 (4): e0154613. DOI: 10.1371/journal.pone.0154613.
- Luthfi M, Elfidasari D, Pairah. 2020. Daily activities of Javan hawk eagle (*Nisaetus bartelsi*) in Bumi Perkemahan Sukamantri Mount Halimun Salak National Park. *J Bios Logos* 10 (2): 99-105. DOI: 10.35799/jbl.10.2.2020.29082. [Indonesian]
- Martinuzzi S, Withey JC, Pidgeon AM, Plantinga AJ, McKerrow AJ, Williams SG, Helmers DP, Radeloff VC. 2015. Future land-use scenarios and the loss of wildlife habitats in the southeastern United States. *Ecol Appl* 25 (1): 160-171. DOI: 10.1890/13-2078.1.
- Maydiantoro A. 2021. Research model development: Brief literature review. *Jurnal Pengembangan Profesi Pendidik Indonesia* 1 (2): 29-35.
- McClure CJW, Schulwitz SE, Anderson DL, Robinson BW, Mojica EK, Therrien J-F, Oleyar MD, Johnson J. 2019. Commentary: Defining raptors and birds of prey. *J Raptor Res* 53 (4): 419-430. DOI: 10.3356/0892-1016-53.4.419.
- Miller EA. 2012. Minimum Standards for Wildlife Rehabilitation 4th edition. National Wildlife Rehabilitators Association, Minnesota.
- Mills R, Taylor GK, Hemelrijk CK. 2019. Sexual size dimorphism, prey morphology and catch success in relation to flight mechanics in the peregrine falcon: A simulation study. *J Avian Biol* 50 (3): jav.01979. DOI: 10.1111/jav.01979.
- Ministry of Environment and Forestry. 2020. The State of Indonesia's Forests 2020. Ministry of Environment and Forestry, Jakarta. [Indonesian]
- Mount Halimun Salak National Park. 2019. Long Term Management Plan for Gunung Halimun Salak National Park 2018-2027 Period. Gunung Halimun Salak National Park Center, Sukabumi. [Indonesian]
- Mullu D. 2016. A review on the effect of habitat fragmentation on ecosystem. *J Nat Sci Res* 6 (15): 1-15.
- Noga SR, Kolawole OD, Thakadu OT, Masunga GS. 2018. Wildlife officials only care about animals: Farmers' perceptions of a Ministry-based extension delivery system in mitigating human-wildlife conflicts in the Okavango Delta, Botswana. *J Rural Stud* 61: 216-226. DOI: 10.1016/j.jrurstud.2018.06.003.
- Nurfatihmah C, Syartinilia, Mulyani YA. 2017. Potential habitat of Javan hawk-eagle based on multi-scale approach and its implication for conservation. *IOP Conf Ser Earth Environ Sci* 54: 012064. DOI: 10.1088/1742-6596/755/1/011001.
- Prawiradilaga DM. 2006. Ecology and conservation of endangered Javan hawk-eagle *Spizaetus bartelsi*. *Ornithol Sci* 5 (2): 177-186. DOI: 10.2326/1347-0558(2006)5[177:EACOEJ]2.0.CO;2.
- Prawiradilaga DM. 2018. Releasing bird wisely back to the wild (Indonesian). <https://www.mongabay.co.id/2018/03/18/opini-pelepasliaran-burung-dan-cara-bijak-melakukannya/>. [Accessed on 2024 25 June].
- Sawitri R, Takandjandji M. 2010. Pengelolaan dan perilaku burung elang di pusat penyelamatan satwa Cikananga, Sukabumi. *Jurnal Penelitian Hutan dan Konservasi Alam* 7 (3): 257-270. DOI: 10.20886/JPHKA.2010.7.3.257-270. [Indonesian]
- Subagja. 2021. Daily behavior and management of the changeable hawk-eagle (*Nisaetus cirrhatus*) at the Kamojang Eagle Conservation Center, West Java. [Thesis]. Institut Pertanian Bogor, Bogor. [Indonesian]
- Syartinilia, Condro AA, Tsuyuki S. 2024. Projected impacts of climate change and anthropogenic effects on habitat distribution of endangered Javan Hawk-Eagle in Indonesia. *Geogr Sustain* 5 (2): 241-250. DOI: 10.1016/j.geosus.2024.01.009.
- Syartinilia, Mulyani YA, Suyitno RA, Condro AA, Tsuyuki S, Van Balen S. 2023. Population estimates of the endangered Javan hawk-eagle based on habitat distribution modeling and patch occupancy surveys. *J Raptor Res* 57 (4): 581-594. DOI: 10.3356/JRR-22-16.
- Tsang LR, McDonald PG. 2019. A comparative study of avian pes morphotypes, and the functional implications of Australian raptor pedal flexibility. *Emu - Austral Ornithol* 119 (1): 14-23. DOI: 10.1080/01584197.2018.1483203.
- Tsang LR, Wilson LAB, Ledogar J, Wroe S, Attard M, Sansalone G. 2019. Raptor talon shape and biomechanical performance are controlled by relative prey size but not by allometry. *Sci Rep* 9: 7076. DOI: 10.1038/s41598-019-43654-0.
- Ulumiyah N, Hernowo JB, Masy'ud B. 2019. Determinant factors of successful release of brahminy kite (*Haliastur indus* Boddaert, 1783) in Kepulauan Seribu National Park. *J Nat Resour Environ Manag* 9 (2): 337-351. DOI: 10.29244/jpsl.9.2.337-351. [Indonesian]
- Utami BD. 2002. Assessment of food potential of Javan Hawk (*Spizaetus bartelsi* Stresemann, 1924) in Mount Salak. [Skripsi]. Institut Pertanian Bogor, Bogor. [Indonesian]
- Wang K. 2020. Analysis on the effect of habitat fragmentation and exploration of its solutions. *IOP Conf Ser Earth Environ Sci* 526 (1): 012001. DOI: 10.1088/1755-1315/526/1/012001.
- Willette M, Rosenhagen N, Buhl G, Innis C, Boehm J. 2023. Interrupted lives: Welfare considerations in wildlife rehabilitation. *Animals (Basel)* 13 (11): 1836. DOI: 10.3390/ani13111836.
- Yue W, Zhou Q, Li M, van Vliet J. 2023. Relocating built-up land for biodiversity conservation in an uncertain future. *J Environ Manag* 345: 118706. DOI: 10.1016/j.jenvman.2023.118706.
- Yuliamalia L, Sunarto, Utami T. 2021. Conservations Javan hawk eagle (*Nisaetus bartelsi*) in Gunung Picis Ponorogo Nature Reserve. *IOP Conf Ser Earth Environ Sci* 940: 012037. DOI: 10.1088/1755-1315/940/1/012037.
- Zhang X, Ren W, Peng H. 2022. Urban land use change simulation and spatial responses of ecosystem service value under multiple scenarios: A case study of Wuhan, China. *Ecol Indic* 144: 109526. DOI: 10.1016/j.ecolind.2022.109526.