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Javan Slow Loris Population and Ecology at a New Site: Mendolo Forest, Central Java, Indonesia

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ABSTRACT

The Javan slow loris (*Nycticebus javanicus*) is a primate endemic to Java Island, Indonesia. Its conservation status has been categorized by IUCN as Critically Endangered, and it is included in Appendix I of CITES. Current population status and distribution remain unrecorded. The research was conducted in Mendolo Forest, Pekalongan Regency, Central Java Province, Indonesia, to estimate population size and distribution patterns. Data collection occurred September 15–19, 2024, using line transect methodology with spotlighting and GPS mapping. The transect locations are in each hamlet of Mendolo Village, namely Sawahan Hamlet with two transects, Mendolo Kulon Hamlet with four transects, Mendolo Wetan Hamlet with two transects, and Krandegan Hamlet with one transect. Data collection on javan slow loris in Mendolo Forest began at 7:30 p.m. to 12 a.m. We identified 8 individuals exhibiting semi-solitary behavior. Javan slow loris in Mendolo Forest are distributed across 3 hamlets, with 3 individuals in Sawahan Hamlet, 4 individuals in Mendolo Kulon Hamlet, and 1 individual in Krandegan Hamlet. The population density of Javan slow loris in Mendolo Forest is 18.35 individuals/km², with the highest density found in Krandegan Hamlet at 33.3 individuals/km² and the

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lowest in Mendolo Wetan Hamlet at 0 individuals/km². The estimated population of Javan slow loris in Mendolo Forest is 21.9 individuals. These findings provide crucial baseline data for conservation management of Javan slow loris populations in Java.

Keywords: Distribution; Nocturnal; *Nycticebus javanicus*; Primate

JEL Codes: Q5; Q23; O57

1. Introduction

Indonesia is one of the megabiodiverse countries with high biodiversity in both flora and fauna. Primates are among the rich fauna found in Indonesia, with 62 documented species including 29 endemic to the country ^[1]. Their distribution spans four major islands: Sumatra (24 species), Kalimantan (14), Sulawesi (16), and Java-Bali (5) ^[2]. Java's extant primates comprise *Presbytis fredericae*, *Hylobates moloch*, *Trachypithecus auratus*, *Macaca fascicularis*, and *Nycticebus javanicus* ^[3].

The javan slow loris belongs to the family Lorisidae, subfamily Lorisinae, and genus *Nycticebus*, which comprises 9 species, with only 7 found in Indonesia ^[4].

The Lorisidae family has an upright body with large, forward-pointing eyes and short, thick hair. The Javan slow loris, or *Nycticebus javanicus*, is considered a subspecies of the sumatran slow loris or *Nycticebus coucang*. However, Groves & Maryanto designated it as a distinct species. Morphological studies by Nekaris & Jaffe ^[5,6], as well as Nekaris & Munds ^[7], and genetic studies by Roos and Okayama and Kurniati ^[8,9], support these studies. According to Supriatna ^[3], this species has a round head with a large snout and rounded nose, and five fingers on the hands and feet that are used for grasping. It has black hair around the eyes that extends to the lower back, and white hair between the eyes that forms a "jeweled" pattern. Its average body length from head to body is 29 cm and it weighs between 750–1150 grams. Just like other species in the *Nycticebus* genus, it does not have a tail. The genus *Nycticebus* has venom obtained by combining saliva from the mouth and oil produced by glands on the arms. *Nycticebus* spp. inject the venom through their teeth ^[10]. Endemic to the island of Java, this primate is included among the 25 most endangered primate species in the world ^[11]. It is known as a nocturnal, small-bodied, semi-solitary animal. Wood sap, flower nectar, and small insects are its

main food sources, along with fruits to fulfill nutritional needs ^[12].

The geographical distribution of the Javan slow loris is generally only known to be centered in western and central Java. However, ecological niche modeling by Thorn et al. estimated the potential for distribution to also occur in the eastern region of Java ^[13]. Javan slow lorises are found in primary forest, secondary forest, mangrove forest, bamboo forest, and plantation areas. The Javan slow loris is the most critically endangered of all slow loris species. This is supported by a statement from the International Union for Conservation of Nature (IUCN), which categorizes the Javan slow loris as critically endangered based on its risk of extinction. All species of the *Nycticebus* genus are also included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which means that all forms of international trade are prohibited ^[14].

The Javan slow loris is a nocturnal animal and can be found in trees (arboreal). It is able to climb and hang on tree branches using only its forelimbs, so it needs tree crowns that are connected to facilitate movement, although it can also pass through the ground. The species is more easily found in plantation areas, agricultural land, and community forest fields than in natural forests (primary or secondary), which is supported by the availability of food sources ^[15–17]. The composition of its diet allows it to adapt to degraded or fragmented environments, such as plantations or smallholder farming areas.

Threats to the Javan slow loris population and habitat are of increasing concern. Poaching and illegal trade are currently threatening its population. In addition, human activities such as deforestation, crop diversification, and land conversion have damaged several of its habitats. This has led to the periodic loss of natural environments, resulting in a diminishing availability of suitable areas for the Javan slow loris. This is in line with the statement by Maolani

et al. that it is now difficult to find Javan slow lorises ^[17], which have been replaced by Sumatran slow lorises in the animal trade market. The reduction of natural habitat will affect the behavior and abundance of Javan slow loris populations in an area ^[18].

Ecological information and data on the Javan slow loris in the wild are still not well recorded, especially in Pekalongan Regency, Central Java Province. Mendolo Forest plays an important role as a source of food reserves for local residents, a germplasm reserve, a source of medicinal materials, and a provider of environmental services such as regulating water systems, preventing erosion, controlling climate patterns, and storing carbon ^[19]. Mendolo Forest is also included among 16 priority locations as habitat for Javan gibbons in Central Java, and therefore can support the existence of other primates ^[20]. In addition, there has been no research on the presence of the Javan slow loris in Mendolo Forest, Pekalongan Regency. Therefore, it is

necessary to conduct research on its presence in the area. This study aims to determine the population estimation and distribution of the Javan slow loris in Mendolo Forest. The information obtained will serve as one of the parameters for managing the species both in-situ and ex-situ, to ensure the sustainability of the Javan slow loris population.

2. Materials and Methods

2.1. Study Site

This research was conducted in Mendolo Forest, Mendolo Village, Lebakbarang District, Pekalongan Regency, Central Java Province. The coordinates of the research location are 7°05'44.6"S, 109°37'51.0"E (**Figure 1**). The study was carried out in several hamlets of Mendolo Village: Mendolo Wetan Hamlet, Mendolo Kulon Hamlet, Krandegan Hamlet, and Sawahan Hamlet.

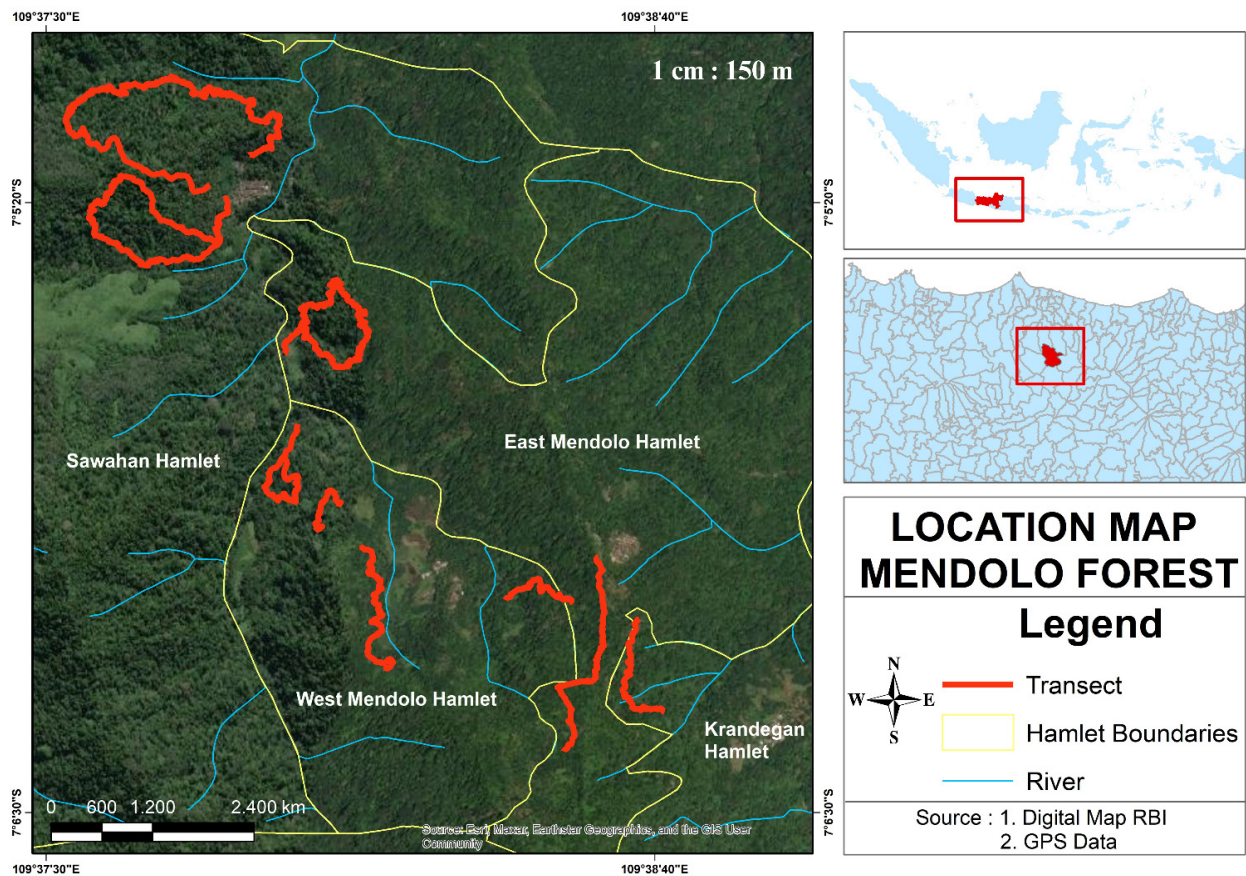


Figure 1. Location of Mendolo Forest, Pekalongan Regency, Central Java, Indonesia.

2.2. Data Collection

This research was conducted from September 15 to 29, 2024. The tools used included binoculars, a camera, Global Positioning System (GPS), Avenza Maps, compass, flashlight or headlamp, tally sheet, stationery, boots, watch, laptop, and ArcGIS Map 10.8. The material used in this study was a map of the Mendolo Forest area. Data were collected by direct observation using the line transect method combined with spotlighting and GPS mapping methods. The line transects were located in each hamlet of Mendolo Village, namely: Sawahan Hamlet (2 transect lines), Mendolo Kulon Hamlet (4 transect lines), Mendolo Wetan Hamlet (2 transect lines), and Krandegan Hamlet (1 transect line). The transect lines ranged in length from 309 to 2,572 meters, with a width of 50 meters (25 meters on each side). The total length of transect lines across the four hamlets in Mendolo Forest was 9.78 km. Each hamlet had a number and length of transects suited to field conditions. Transect lines were placed at specific locations to represent the population as sample plots. This aligns with the statement by Bismark ^[21], who noted that transect placement can be random or based on known animal habitats to aid in inventory and presence data collection. Furthermore, according to Iswandaru et al. ^[22], transect locations were selected based on previously recorded encounter data, habitat types, and supporting food sources.

Data collection was carried out once for each transect line. Observations were conducted at night to determine the presence of Javan slow lorises. Observation times in Mendolo Forest were from 19:30 to 24:00 WIB. This follows the statement by Rodliyya ^[23], who noted that night observations should be conducted during the active period of the Javan slow loris, from 17:30 to 23:00. Additionally, according to Pambudi ^[24], the Javan slow loris becomes active after sunset, with peak activity between 20:00 and 22:00, and declining from 23:00 to 24:00.

Observations were performed using a flashlight or headlamp to detect the reddish eye-shine of the lorises when exposed to light. The position of the Javan slow loris was documented with a camera, and coordinates were recorded using a GPS. Tally sheets recorded the coordinates, number of individuals, sex or age class (if known), time of

day, distance to the observer, angle (α), and distance to the transect line. Additional data on Javan slow loris encounters were gathered through secondary sources, such as information provided by local farmers or communities near the research site.

2.3. Data Analysis

2.3.1. Population Density

The population density of the Javan slow loris was calculated using the formula by Winarti ^[25]:

$$\text{Population Density (individuals/km}^2\text{)} = \frac{\text{number of individuals identified}}{\text{total study area} * \text{number of replicates}} \quad (1)$$

2.3.2. Population Estimation

The population estimate of the Javan slow loris was determined using the formula by the Subcommittee on Conservation of Natural Populations ^[26]:

$$P = d * a \quad (2)$$

where P is the population estimate, d is the population density (individuals/km²), and a is the area of the habitat (km²).

2.3.3. Distribution Pattern

GPS data of Javan slow loris sightings were mapped using ArcGIS 10.8 to produce a location map of their distribution in Mendolo Forest.

3. Results and Discussion

3.1. Javan Slow Loris Population

The research found 8 individual Javan slow lorises at 7 encounter points in Mendolo Forest (**Table 1**). The number of observation transect lines in each hamlet varied because the selection of transect lines was based on community information related to the presence of the Javan slow loris around Mendolo Forest. According to Iswandaaru et al. ^[22], transect locations are selected based on previously recorded encounter data, habitat type, and supporting food sources.

Table 1. Javan Slow Loris Encounter Points in Mendolo Forest.

No	Coordinates	Number of Individuals	Hamlet Location	Description
1	7°05'12"S 109°37'33"E	1	Sawaham Hamlet	Teens
2	7°05'18"S 109°37'41"E	1	Sawaham Hamlet	Adults
3	7°05'20"S 109°37'35"E	1	Sawaham Hamlet	Adults
4	7°05'52"S 109°37'56"E	2	Mendolo Kulon Hamlet	Adult & Child
5	7°06'10"S 109°38'06"E	1	Mendolo Kulon Hamlet	Teens
6	7°06'04"S 109°38'28"E	1	Mendolo Kulon Hamlet	Adults
7	7°06'17"S 109°38'37"E	1	Krandegan Hamlet	Adults

Results showed that the Javan slow loris in Mendolo Forest was found to be semi-solitary (**Figure 2**). This condition occurred because, at the time of the research, a mother and her offspring were found together at one location point. This is consistent with the statement by Romdhoni et al. ^[27], who noted that Javan slow lorises are rarely found with other individuals, except when

they have offspring or mates. Javan slow lorises are often observed moving alone in their natural habitat, indicating that they are solitary animals and rarely socialize ^[28]. However, recent studies have reported that the Javan slow loris is not strictly solitary but is more likely to be considered a semi-solitary primate that can form spatial groups ^[17–18].



Figure 2. Javan Slow Loris in Mendolo Forest, Central Java, Indonesia. Photo by M.Y. Saputra.

There is one hamlet where the Javan slow loris was not found, namely Mendolo Wetan Hamlet. According to information from the community, in the past year, Javan slow loris encounters were recorded around the research transect lines, but changes in forest vegetation structure caused by the local community converting land to agricultural crops have made the previously suitable habitat unsuitable. As shown in **Figure 3**, the forest in Mendolo Wetan Hamlet now has less dense vegetation, which hinders the movement of the Javan slow loris (**Figure 3(A)**). This aligns with the statement by Romdhoni et al. that the Javan slow loris cannot jump ^[27], and its movement depends on vegetation connectivity to move from one tree to

another. Therefore, Mendolo Kulon Hamlet had the most Javan slow loris encounters because it has interconnected vegetation that facilitates their movement (**Figure 3(B)**). Habitat loss and fragmentation have pushed the Javan slow loris population into small, isolated groups in the remaining natural forests on Java Island ^[29]. This is supported by Widiana et al. ^[30], who state that habitat fragmentation or plant uniformity affects food sources and living space, contributing to the population decline. Apart from these factors, Javan slow loris activity is influenced by weather conditions. According to Starr et al. ^[31], loris activity increases when the moon shines brightly but tends to decrease or become silent during rain.



Figure 3. Differences in Forest Vegetation Structure. (A) Mendolo Kulon Hamlet, (B) Mendolo Wetan Hamlet. Photo by M.Y. Saputra.

Based on information from residents, certain areas of Mendolo Forest are often used as hunting grounds for wildlife such as birds, pigs, deer, and others, using air rifles either in groups or independently. This hunting activity is one of the factors that make it difficult to find the Javan slow loris in Mendolo Forest. However, some people in Mendolo Village believe that the Javan slow loris is an animal that brings bad luck. According to residents, the mystical belief is that if the Javan slow loris is deliberately captured or enters people's homes, the household will experience disaster. The animal is considered sacred to encourage it to remain awake and free in the wild. This aligns with the statement from Rahayu that local wisdom aims to maintain nature, especially the animals and plants around it, so they are preserved [32].

3.2. Population Density

The population density value of the Javan slow loris

is determined by the number of identified individuals and the area of the transect in each study site multiplied by the number of replicates. The distribution of Javan slow loris on Java Island shows different encounter rates, with some areas having high and others having low encounter rates [33]. This is due to each encounter site on Java Island having a different habitat type. These differences are influenced by variations in habitat type, research methods used, and research timing. The duration or timing of research is considered sufficient or optimal if it does not result in significant changes in the results [25]. In addition, differences in Javan slow loris population density vary not only by habitat type but also by observation year [34]. The highest population density occurred in Krandegan Hamlet, which had the shortest total length of observation transect lines of 582 meters. The density of Javan slow loris individuals ranged from 0 to 33.3 individuals/km², with an average of 18.35 individuals/km² in Mendolo Forest (Table 2).

Table 2. The Density of Javan Slow Loris Individuals in Mendolo Forest.

No.	Hamlet Location	Number of Individuals	Total Area (km ²)	Value (Individuals/km ²)
1	Sawahan	3	0.216	13.8
2	Mendolo Kulon	4	0.114	26.3
3	Mendolo Wetan	0	0.129	0
4	Krandegan	1	0.030	33.3
Average				18.35

The mean population density value in Mendolo Forest is higher than in Bedogol Forest of Gunung Gede Pangrango National Park, which has a value of 15.29 individ-

uals/km² [24], and in Mount Tampomas Nature Park, which has only 7.64 individuals/km² [35], but lower than in Talun Tasikmalaya and Ciamis, where the value is 25.52 individ-

uals/km² ^[25]. High population density and number of Javan slow loris individuals are generally found in habitats with a good level of comfort and safety, indicated by the availability of food sources, sleeping vegetation, and low surrounding threats ^[30].

3.3. Population Estimation

Population estimates of the Javan slow loris are influenced by individual density values and the area of representative habitat used as research sites. When the area is the same, the individual density value can illustrate habitat quality in that area. Representative habitat refers to the entire study area and its surroundings that may be used as habitat for the Javan slow loris ^[25]. Representative habi-

tat was determined from the locations of Javan slow loris encounters during the study. After confirming presence, the representative habitat area was further identified using local community information and the presence of similar habitat types nearby. From this calculation, Mendolo Forest was estimated to have a total population of 21.9 individuals (**Table 3**). The largest population estimate was in Mendolo Kulon Hamlet with 11 individuals, and the smallest in Mendolo Wetan with 0 individuals because no Javan slow loris was found there during the study. The population estimate in Mendolo Forest is greater than that of Mount Tampomas Nature Park with 11 individuals and Sindulang Village Talun with 21 individuals ^[30,35], but lower than in Tasikmalaya and Ciamis Talun with 466.52 individuals ^[25].

Table 3. Population Estimation of Javan Slow Loris in Mendolo Forest.

No	Hamlet Location	Representative Habitat (km ²)	Value
1	Sawahan	0.41	5.6
2	Mendolo Kulon	0.42	11
3	Mendolo Wetan	0	0
4	Krandegan	0.16	5.3
Total		0.99	21.9

According to IUCN (2024), the population of the Javan slow loris is currently estimated to have decreased by 80%. Nekaris & Nijman stated that the main factor influencing the decline in Javan slow loris population density is the loss of habitat ^[18]. This aligns with the research of Nekaris & Jaffe ^[6], who stated that the primary causes of the decline are loss of native habitat and habitat disturbance in the wild. Continuous habitat fragmentation has a prolonged impact on the Javan slow loris, forcing it to adapt or adjust to the surrounding environment. In addition, the Javan slow loris's low reproductive capacity makes it very vulnerable to population decline ^[34].

3.4. Distribution

The existence of the Javan slow loris in Mendolo Forest is part of the distribution results in the Dieng Mountains ^[7]. Thorn et al. predict the distribution of the remaining Javan slow loris on Java Island ^[13], including the Dieng Mountains. The results of research by Sodik et al. (2020) show that suitable habitat for the Javan slow loris is found in the northern part of Central Java ^[14], with several areas

in the southern part of Central Java. The habitat of the Javan slow loris in Central Java is mostly fragmented. The Javan slow loris has an uneven distribution, with indications that the population is only temporary ^[33]. The coordinates of encounter points for the Javan slow loris throughout Mendolo Forest are projected on a distribution map (**Figure 4**).

The distances between encounter points for the Javan slow loris in Mendolo Forest are presented in **Table 4**. Individuals or groups of slow lorises occupy habitats with overlapping roaming areas. Male Javan slow lorises tend to protect their own territory and their partner's territory from other slow lorises when paired ^[25]. According to Wiens ^[36], males have larger home ranges than females because their roaming areas overlap with all family members. The relatively small habitat size can result in small and overlapping roaming areas for the Javan slow loris ^[25]. In Mendolo Forest, the distances between encounter points range from 0.19 to 2.81 km, with a total representative habitat area of 0.99 hectares. The shortest distance, 0.19 km, is between the first and third encounter points

in Sawahan Hamlet, while the longest distance, 2.81 km, is between the first encounter point in Sawahan Hamlet and the seventh point in Krandegan Hamlet. Nurcahyani (2015) reports that the Javan slow loris has a nightly

range of approximately 0.35 to 0.45 km. In Mount Halimun Salak National Park, the home range is about 2.25 to 5.58 hectares^[37], and in Masigit Kareumbi Hunting Park, it ranges from 0.4 to 8.9 hectares^[23].

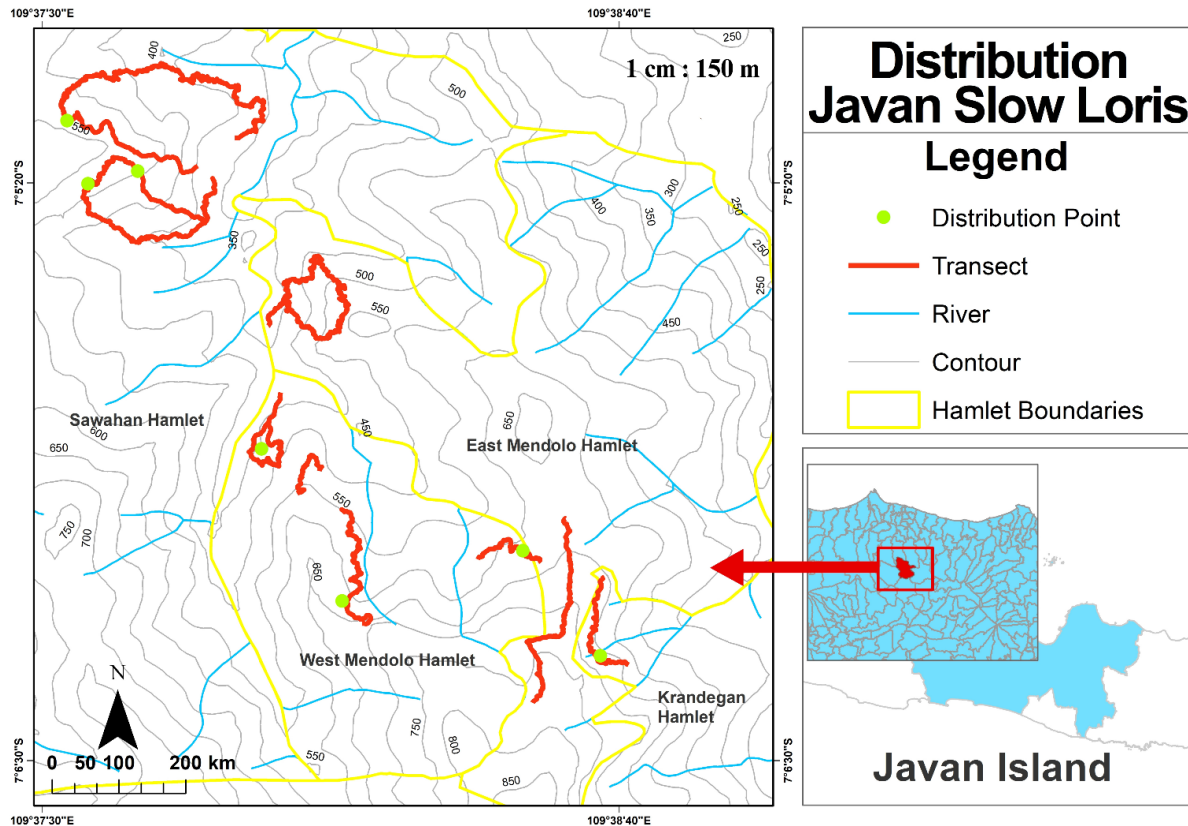


Figure 4. Distribution map of Javan slow loris in Mendolo Forest.

Table 4. Distances Between Encounter Points of Javan Slow Loris (km).

Point	1						
2	0.32	2					
3	0.25	0.19	3				
4	1.42	1.13	1.18	4			
5	2.06	1.77	1.82	0.64	5		
6	2.33	2.01	2.12	1.04	0.7	6	
7	2.81	2.5	2.59	1.48	0.98	0.49	7

The presence of the Javan slow loris in Mendolo Forest is closely linked to the availability of supporting food sources. Observations show that their food sources in Mendolo Forest include trees such as coffee, durian, and jackfruit, from which the slow loris obtains sap. Sap is their preferred food, as supported by Sholihah^[34], who reported that in their natural habitat, Javan slow loris consume sap the most (70.24%), followed by nectar (16.67%), insects

(11.29%), and flowers (1.19%). Furthermore, Wirdateti noted that slow lorises are commonly found in secondary forests where food sources like sap, fruits, insects, and small reptiles are available^[38]. The Javan slow loris uses its home range for activities such as feeding and sleeping. Food availability influences their daily range: when food is abundant, their daily range tends to be shorter; when food is scarce, the daily range is longer^[39]. The size of the Javan

slow loris home range can also vary annually due to factors such as climate change, food availability, competition, human activities, and forest fragmentation^[40].

The distribution of the Javan slow loris in Mendolo Forest, based on topography, is generally found on steep and sloping hillsides. The results showed that Javan slow lorises in Mendolo Forest were observed at altitudes between 480 and 640 meters above sea level (asl). Other studies have reported Javan slow loris presence at various altitudes: 479–899 m asl^[41], 1275–1570 m asl^[42], 220–1600 m asl^[6], 50–1100 m asl^[43], and 1350–1650 m asl^[11]. Besides altitude, the availability of water sources also supports Javan slow loris habitat. This aligns with Sodik's research^[14], which identifies water sources as a key factor for the survival of wild animals.

4. Conclusions

The study found 8 individual Javan slow lorises distributed semi-solitarily across 7 encounter points in Mendolo Forest. These individuals were spread over three hamlets: 3 in Sawahan Hamlet, 4 in Mendolo Kulon Hamlet, and 1 in Krandegan Hamlet. The population density values were 13.8 individuals/km² in Sawahan Hamlet, 26.3 individuals/km² in Mendolo Kulon Hamlet, 0 individuals/km² in Mendolo Wetan Hamlet, and 33.3 individuals/km² in Krandegan Hamlet, resulting in an average population density of 18.35 individuals/km² across Mendolo Forest. The estimated population sizes were 5.6 individuals in Sawahan Hamlet, 11 in Mendolo Kulon Hamlet, 0 in Mendolo Wetan Hamlet, and 5.3 in Krandegan Hamlet, with a total estimated population of 21.9 individuals in Mendolo Forest. The presence of the Javan slow loris population in Mendolo Forest confirms that viable populations still exist in Central Java, making this information important for conservation planning and management strategies on Java Island, Indonesia.

Author Contributions

Conceptualization, M.Y.S., I.N.N., G.M., A.S.; methodology, M.Y.S., I.N.N., G.M., A.S.; investigation, M.Y.S., A.S.; data analysis, M.Y.S., I.N.N., G.M.; visualization, M.Y.S., I.N.N., G.M.; resources, M.Y.S., I.N.N., G.M.,

A.S.; writing—original draft preparation, M.Y.S., I.N.N., G.M.; writing-review and editing, M.Y.S., I.N.N., G.M.; visualization, M.Y.S., I.N.N., G.M.; supervision, I.N.N., G.M., A.S.; project administration, M.Y.S., I.N.N., G.M., A.S.; funding acquisition, I.N.N., A.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

All raw data are not publicly available; however, the corresponding author can be contacted for further information.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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