

# Population study of long-tailed macaque (*Macaca fascicularis*) on Deli Island, Banten, Indonesia

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**Abstract.** Fitriana YS, Sulistyadi E, Tohir RK, Hasibuan MM, Rifaie F, Maryanto I, Lubis AM, Rifqi MF. 2024. Population study of long-tailed macaque (*Macaca fascicularis*) on Deli Island, Banten, Indonesia. *Biodiversitas* 25: 129-135. Understanding the distribution and population dynamics of primate species is essential for practical conservation efforts. However, such information is often unavailable, even for species whose populations appear abundant. The long-tailed macaque (*Macaca fascicularis* Raffles, 1821) is a species with a wide range in Southeast Asia, including Sumatra, Java, Kalimantan, Bali, Lombok, and Lesser Sunda in Indonesia. However, comprehensive data on population density across its Indonesian distribution area still needs to be improved. To address this knowledge gap, we conducted a thorough survey and study to estimate the population density of long-tailed macaques on Deli Island, located in Banten Province. Long-tailed macaques were introduced to Deli Island between 1989 and 1990 with a total of 1000 males and 10,000 females. To date, a total of 9,500 individuals have been harvested from this island in the period 1991-2010. We employed the line transect distance sampling (LTDS) method with a perpendicular distance approach that covered all habitat types throughout the island. Our findings revealed that the population density of long-tailed macaques on Deli Island is approximately five individuals per hectare, with an estimated total population of 4,860. The data pertaining to age structure and sex ratio is notably limited, primarily due to challenges in identification caused by dense vegetation. To address these limitations and acquire a more comprehensive understanding, additional research is essential for the accurate determination of the age structure and sex ratio on the island. Our study provides crucial baseline data for conserving this species. We recommend implementing a systematic survey encompassing the entire distribution range of the long-tailed macaque across Indonesia. Such an initiative will be instrumental in assessing its threat status and laying out a comprehensive plan for conservation efforts.

**Keywords:** Abundance, conservation, Deli Island, density, long-tailed macaque, population

**Abbreviations:** LTM: Long-tailed macaque

## INTRODUCTION

The long-tailed macaque (*Macaca fascicularis* Raffles, 1821) is a primate species with a widespread and nearly consistent presence across Southeast Asia (Hansen et al. 2021; Gamalo et al. 2023). In Indonesia, the natural range of this population encompasses Sumatra, Java, Kalimantan, the surrounding smaller islands, and the Lesser Sunda Islands, which includes Bali, Lombok, and Nusa Tenggara (Sajuthi et al. 2016). Internationally, according to the most recent assessment by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species in 2022, this species has been classified as endangered (EN) (Hansen 2022). It is reported that there has been an increase from its previous status as vulnerable (VU) in 2020-2021. This reclassification is attributed to a continued decline in the population due to factors such as local hunting, national and international trade, and rapid

development across Southeast Asian countries, which have led to a significant reduction in its natural habitat.

Moreover, the long-tailed macaque (LTM) is also listed in CITES Appendix II, which means that international trade in this species is regulated through a quota system. The growth in human population and the economy is believed to drive an increased demand for wild animals, including this species, for commercial purposes and non-commercial use, including biomedical research (Sajuthi et al. 2016; Sayektiningsih and Broto 2021). According to Sayektiningsih and Broto (2021), the LTM is one of the five primate species most widely used in medical research and is extensively exported to Japan and the United States. Additionally, this trade involves the utilization of macaque skulls for ornamental accessories, their skin for hat production, the consumption of their meat for traditional medicine and dietary purposes, and as pets. Notably, there is an emerging trend of exploitation in social media for

entertainment purposes, further contributing to the multifaceted challenges posed by this trade (Gamalo et al. 2023).

Uncontrolled trade poses a significant threat to the sustainability of the LTM population. LTM is part of the international primate trade (Nijman and Healy 2016). The global trade cumulative in this species reached 450,000 individuals between 2008 and 2019 (Hansen et al. 2021). Indonesia has been an exporting country since 1970 and is one of the leading exporters of the LTM. Indonesia has documented 440 transactions involving LTM over a span of 30 years (1990-2019). These transactions encompass both live animals and non-live forms. Notably, the trade in live macaques has resulted in a substantial total of 117,193 individuals (Sayektiningsih and Broto 2021). This extensive utilization raises concerns about the potential scarcity and even the extinction of the LTM in the future. While some locations in Indonesia, particularly in North Sumatra, report LTM becoming a pest, there is a notable absence of further studies on the population dynamics in that specific region (Kuswanda et al. 2023). As a result, it is imperative to adopt systematic measures for the sustainable management and utilization of this species. Among the essential activities required to establish utilization quotas, conducting a comprehensive survey of the LTM population in Indonesia is a fundamental step.

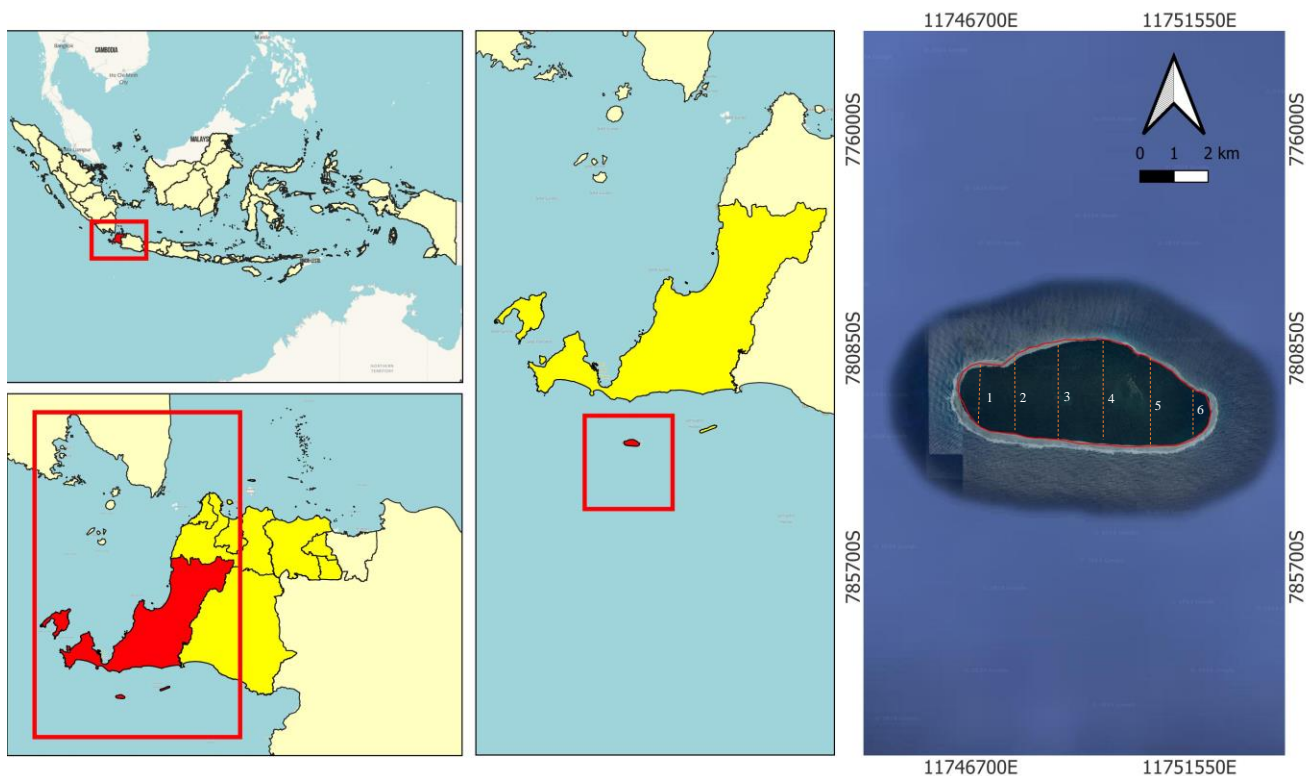
Information about the LTM population in various regions remains limited. The government, along with other stakeholders, has conducted population studies/estimations in some areas, but these efforts have been constrained in

their coverage. Extensive population surveys are needed to comprehensively address LTM management concerns in Indonesia. The urgency of conducting these surveys is twofold. Firstly, it plays a vital role in determining catch quotas for the LTM as export commodities. Secondly, it contributes to establishing a comprehensive database documenting potential populations of this species across Indonesia. Such a database will be an asset for informing and guiding conservation programs. One region that holds promise for the LTM populations is Deli Island in Pandeglang, Banten Province, Indonesia. The objective of this research is to gather population data, providing a fundamental basis for the effective management of the LTM population.

## MATERIALS AND METHODS

### Study area

Deli Island is a small island situated to the south of Java Island, which is precisely located at coordinates  $7^{\circ}01'00''\text{S}$ ,  $105^{\circ}31'25''\text{E}$  (Figure 1). Administratively, Deli Island falls under the jurisdiction of the Pandeglang District in Banten Province, Indonesia. Deli Island boasts an area of approximately 11,183 km<sup>2</sup> during low tide and 9,469 km<sup>2</sup> during high tide, featuring predominantly lowland terrain with gently sloping topography. Notably, this island is uninhabited and functions as a protected forest area under the management of *Perhutani*.



**Figure 1.** Aerial map of Deli Island, Pandeglang District, Banten Province, Indonesia and its position from Java Island with six transects are deployed, extending from south to north, with varying lengths ranging from 900m to 2.2 km

The ecosystem of Deli Island comprises coastal forests, primarily located on the eastern and southern sides of the island, and lowland forests on its northern side. The northern side consisted of various large woody trees with a dense canopy, dominated by species such as *Intsia bijuga* (Colebr.) Kuntze, *Syzygium densiflorum* Wall. ex Wight & Arn., *Decapernum paniculatum* (Lindl.) Kurz, *Eugenia cupre* (O.Berg) Mattos, and *Ficus ampelas* Burm.f. Additionally, *Terminalia catappa* L., *Calophyllum inophyllum* L., *Hernandia nymphaeifolia* (C.Presl) Kubitzki, and *Pterospermum javanicum* Jungh. trees along the coast are unique vegetation absent on the southern side. The eastern and southern regions of the island have different landscapes, covered with *Hibiscus tiliaceus* L., *Pandanus* spp, *Cerbera manghas* L., and various understory plants. In the heart of the island, there is a substantial swamp, and during the rainy season, many areas in the central region become flooded, resembling small swampy areas. The vegetation in the central area mainly consists of trees typical of lowland forests, including *Nauclea orientalis* (L.) L., *D. paniculatum*, and *E. cupre*. The extensive swamp in the island's center is primarily covered by *Actinoscirpus grossus* (L.f.) Goetgh. & D.A.Simpson, with pockets of algae found in deeper puddles.

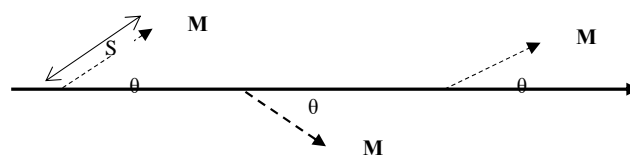
The LTM is an animal that has been introduced to Deli Island. Besides LTM, the island is home to monitoring lizards, pythons, kingfishers, pigeons, and several other bird species. It is worth noting that there is no hunting of LTM on Deli Island, and the island's visitors primarily consist of fishermen seeking fish and lobsters.

### Data collection

We took great care to avoid capturing, handling, or causing any harm to the LTM, throughout our research on Deli Island. The study was conducted between June 25<sup>th</sup> and July 7<sup>th</sup>, 2022. The LTM population estimation study was conducted using the transect method, explicitly utilizing the Line Transect Distance Sampling (LTDS) approach with a perpendicular distance technique (Buckland et al. 2016). Observations were carried out as an observer moved along the transect line following predetermined positions and directions. We determined the locations and number of transect lines at the study site before conducting the study. In total, six transect lines were positioned across Deli Island, extending from the north coast to the south edge of the island. These lines were

spaced at 1 km intervals, as illustrated in Figure 1, and covered various habitat types. We adhered to all the critical assumptions of the LTDS method, ensuring the detection of objects on the line or point with certainty, detecting objects at their initial location, and recording precise measurements. The transects are spaced approximately 1 km apart, following a systematic and random pattern relative to the animal habitat and distribution (Buckland et al. 2015). The length of each transect varies depending on the island's width (Table 1).

The study was conducted by three separate groups of observers (each group comprises three persons) who simultaneously walked on three adjacent transect lines starting from point 0 on each transect. Observations were conducted from 06:00 to 10:00 a.m. and from 02:30 to 06:00 p.m., following the sun's position in the Deli Island area. Both morning and evening observations constituted a single observation unit. We repeated one repetition on the same transect the following day to assess the consistency of the observed LTM groups. The walking speed was maintained at approximately 1.6 km/h (Glennie et al. 2021). Recordings were made when LTM were detected and identified based on their visual appearance (Plumptre and Cox 2006). Each observation at an encounter point lasted between 15 and 20 minutes. In addition to gathering population data, we recorded the direction of the macaques' movement to prevent double counting caused by animals passing in front of the observer (Buckland et al. 2015). The recorded data included the number of individuals, coordinates of the encounter point, angle and distance of the encounter, age class, sex and activity of the LTM (Figure 2). We determined the sex of LTM by examining genitalia (scrotum for males) and nipples (for females). Additionally, ongoing activities such as breastfeeding an infant were considered for further confirmation.



**Figure 2.** Illustration of observation path; M: animal point; S: observer distance to animal;  $\theta$ : animal angle to the observer

**Table 1.** Position and length of each line transect at the study area in Deli Island, Pandeglang District, Banten Province, Indonesia

Transect	Initial coordinates		Final coordinates		Length (m)
	X	Y	X	Y	
1	105,5221365	-7,001347136	105,5221458	-7,010024424	959,63
2	105,5313594	-6,999476323	105,5313759	-7,014025161	1608,97
3	105,540581	-6,996142686	105,5406027	-7,015007517	2086,28
4	105,5498055	-6,995443062	105,5498293	-7,015787059	2249,86
5	105,5590358	-6,99961759	105,5590554	-7,016120634	1825,09
6	105,5682593	-7,005694611	105,5682478	-7,013921416	909,81

### Data analysis

We conducted data analysis on the observations collected using the LTDS method to calculate density values, determine age classes, sex ratio, and estimate the population of LTM. We focused solely on the data gathered during the designated morning and evening observation periods. Data collected outside of these specified times was still recorded for use in other aspects of the study, serving to prevent any potential issues related to double counting. It is crucial to analyze and identify LTM groups observed within each transect before calculating population density. This step is essential to minimize the potential for double counting bias. For this purpose, we applied the minimum enclosing circle method to analyze and identify observed macaque groups (Gao and Wang 2018). All encounter coordinate points with LTM were input into Geographic Information System (GIS) software, specifically ArcMAP 10.8 and ArcGIS Pro 3.0. The macaque groups were then identified based on point coordinates and encounter times. When two or more observation points were found within a distance of less than 100 meters, they were combined into a single group. This distance threshold was determined based on the observer's typical visibility range of no more than 50 meters. The combination of observation coordinate points also factored in the time of encounter and specific characteristics used to distinguish the macaque groups, including the number of individuals, sex composition, and age groups observed at neighboring coordinate points. The minimum enclosing circle method was employed to establish the center point of each group, guiding the grouping process (Gao and Wang 2018). The method used for calculating the population density of LTM is as follows:

#### Observation plot width

$$L_t = \frac{j_1 + j_2 + j_3 + j_4 + \dots + j_n}{n} \times 2 \dots j = S \times \sin \theta$$

Where:

- L<sub>t</sub> : transect width
- j : distance
- n : number
- S : distance between observer and animal
- θ : animal angle

#### Density

$$K = \frac{N}{L} \dots L = L_t \times j$$

Where:

- K : density
- N : number of individuals
- L : plot area,
- L<sub>t</sub> : transect width,
- j : distance

Estimating the population abundance using line transect methods requires extrapolation based on population density values. In this study, we calculated the estimated population abundance of the LTM on Deli Island by multiplying the population density value obtained by the total area of the island, which covers 960 hectares.

## RESULTS AND DISCUSSION

### The history of island management and the current condition

Deli Island serves as a site for the Natural Habitat Breeding Facility (NHBF) program for a free-ranging population of LTM. This initiative traces its origins to a 1981 WHO meeting that explored the potential for establishing national programs within habitat countries to sustainably manage primate populations as "renewable" resources (Kyes et al. 2012). In Indonesia, regulations governing animal breeding endeavors are delineated in the Minister of Forestry Regulation No. P.19/Menhut-II/2005 pertaining to Wild Plant and Animal Breeding. The NHBF framework aligns with these regulations through the implementation of semi-in situ captive breeding practices. The management of the Natural Habitat Breeding Facility (NHBF) is regarded as effective, as it ensures the well-being of LTM and provides additional benefits despite the substantial costs associated with its implementation. The NHBF program could be aligned with determining harvest quotas regulation by incorporating key factors such as habitat distributions, population size, sex ratio, and animal welfare (BRIN and KLHK 2023). These factors serve as crucial determinants in shaping policies related to harvest quotas. The NHBF approach prioritizes sustainable practices that consider both ecological and ethical considerations in the management of wildlife populations. Furthermore, NHBF represents a strategic management paradigm that effectively bridges market demands with overarching conservation goals (Kyes et al. 2012).

LTM was introduced to Deli Island between 1989 and 1990 with a total of 1000 males and 10,000 females. To date, a total of 9,500 individuals have been harvested from this island in the period 1991-2010. Harvesting activities concluded in 2010, yet management efforts on the island, which encompassed infrastructure maintenance and the provision of supplementary feed for LTM, persisted until 2014. Between 2014 and 2021, management activities were limited, focusing mainly on island security, and offering minimal supplementary feed. In 2022, a renewed phase of management commenced, characterized by facility reorganization and the initiation of population surveys.

### Density and population structure

The total length of the observation transects was 9,640 meters, with a transect width calculated using a perpendicular distance of 55 meters. This results in a sampling area of 53 hectares, approximately 5.6% of Deli Island's total area (9,660 hectares). A total of 278 individuals were observed, with their distribution as follows: 25 in transect 1, 106 in transect 2, 21 in transect 3, 47 in transect 4, 59 in transect 5, and 20 in transect 6. Based on the analysis, the estimated density of LTM across Deli Island is five individuals per hectare. The estimated LTM population on Deli Island, which covers an area of 960 hectares, is 4,860 individuals. Based on the data, spanning the 11-year period from 2010 to 2021, during which LTM harvesting ceased, there is evidence of population growth at this site. This growth could

potentially be attributed to the island's conditions, which seemingly meet the dietary and spatial requirements of the LTM. This observation aligns with the assertion by Hilborn and Smith (2023) that the species has demonstrated a growth rate of 7-10% annually from diminished populations, thereby significantly minimizing the risk of extinction. This research indicates a growth trend in the population on Deli Island. Therefore, it underscores the importance of continued management and conservation efforts to sustain this positive population trajectory. Moving forward, it would be prudent to evaluate the habitat's carrying capacity for the LTM to ensure sustainable management and conservation efforts. According to (Perwitasari-Farajallah et al. 2023), it is essential to assess the population of LTM to ensure it is below carrying capacity.

The age structure of LTM in Deli Island that could be identified is dominated by approximately 30% adults, 14% juveniles and 56% unidentified (Figure 3A). The observed sex of the adult LTM population in Deli Island is 12% male, 3% female, and 85% unidentified (Figure 3B). Based on the analysis, the age structure and sex ratio of LTM in Deli Island are mostly unidentifiable because, during observation, the Macaques were high above the canopy (approximately 20 meters) and concealed behind foliage. Males typically dominate encounters due to their inherent physiological and behavioral characteristics, which may include larger body size, increased aggression levels, and a desire to assert dominance within their social hierarchy (Komala et al. 2017; Afifah et al. 2022). Despite the limitations in the available data, the sex ratio of LTM on Deli Island is identified as four males to one female. Consequently, there is a recognized need for more comprehensive research to discern the age and sex structure of the LTM population on Deli Island.

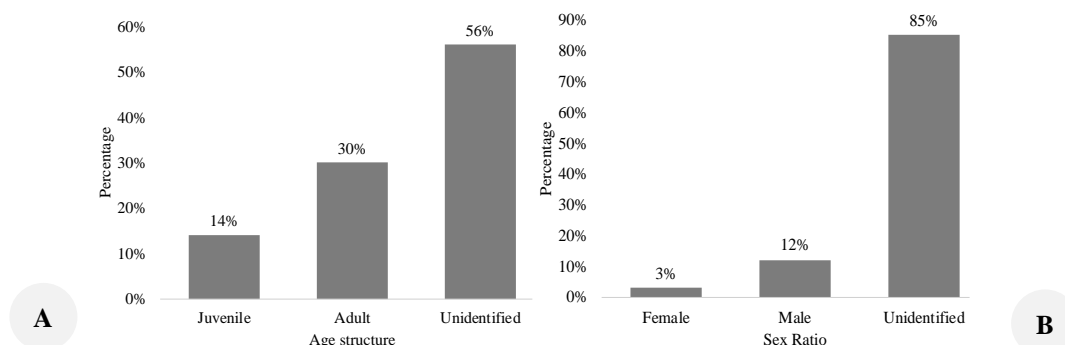
All Macaque species exhibit a social organization comprising several male and female individuals within their colonies (groups). They adopt a promiscuous mating system where male and female macaques generally mate with multiple partners, known as multimale multifemale (Al-Hakim et al. 2023). LTM live in groups consisting of a multi-male multi-female family with a robust hierarchical structure within the group, leading to alpha and beta male and female macaques (Kamarul et al. 2014). Considering this, the sex ratio of LTM on Deli Island is not conducive to their population's growth and dynamics. To ensure a

healthy and sustainable population on Deli Island. The sex ratio plays a pivotal role in shaping the dynamics of group competition. Specifically, when the count of adult males surpasses that of females, it intensifies competition among adult males within the group (Vrazila et al. 2022).

Although the behavior of LTMs was monitored without employing quantifiable methods, our observations revealed that the LTMs on the island exhibit strong wild tendencies. They typically display apprehension towards human encounters, often retreating and emitting warning calls to notify fellow group members of potential human threats. LTM were very sensitive animals (always alert), especially in threatened conditions (Kamarul et al. 2014). The observed behaviors encompassed activities such as feeding, parenting, mating, and vocalizations (Figure 4). The daily behaviors of LTM, including moving (moving places), grooming, playing, inactive, eating, agonistic (fighting), sleeping, mating, and making sounds (Stark et al. 2019). This suggests that the behavior of LTMs on Deli Island remains consistent with their natural tendencies, and the habitat continues to adequately fulfill their requirements.

#### Long-tailed macaque colony

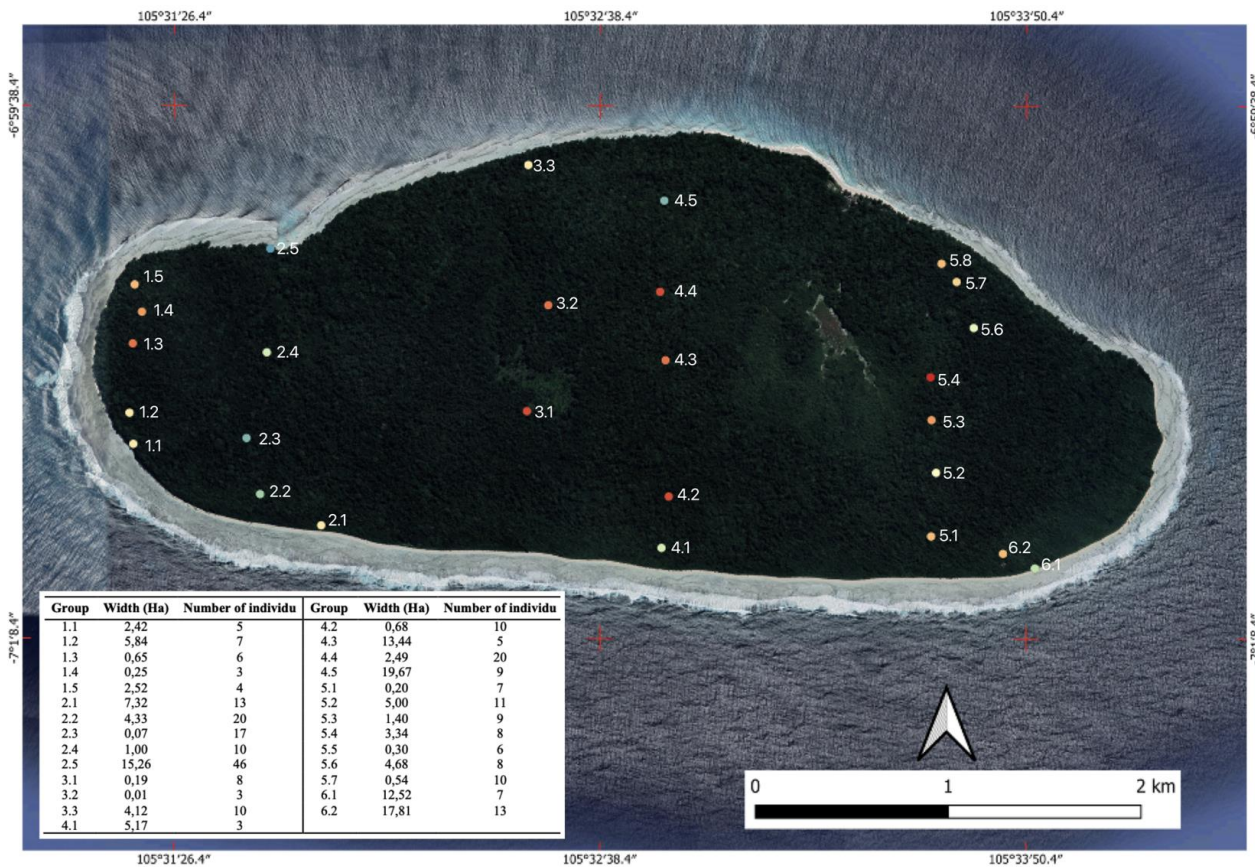
Utilizing the minimum enclosing circle method within ArcMAP 10.8 and ArcGIS Pro 3.0 software, the analysis provided estimates of the group quantities observed along each transect line and the extent of foraging areas occupied by LTM groups in Deli Island. In total, 107 encounters of LTM were documented across all the study's transect lines. According to the analysis involving the minimum enclosing circle method, it is estimated that there are 27 LTM groups in Deli Island, as deduced from data collected along the six observation transects. On average, each group's daily moving and foraging territory covers approximately 500 m<sup>2</sup>. According to Mohammad and Wong (2019), the predominant daily activities exhibited by LTMs include movement and foraging. The largest group, known as Group 2.5, comprises 46 observed individuals found on transect two and inhabits a territory area measuring 15.26 hectares (Figure 5). Another research revealed that the home ranges for LTMs span between 6.26 and 13.8 hectares (Bunga et al. 2023). Given that this species establishes territories within its colonies, it is plausible to infer the presence of additional, unobserved colonies dispersed throughout the island.



**Figure 3.** A. Age class; and B. Sex of long-tailed macaques in Deli Island, Pandeglang District, Banten Province, Indonesia



**Figure 4.** The behavior of the Long-tailed macaque in Deli Island, Pandeglang District, Banten Province, Indonesia. A. Feeding; B. Parenting; C. Mating and reproduction; D. Vocalizations



**Figure 5.** The map of Deli Island, Pandeglang District, Banten Province, Indonesia, with the distribution, daily foraging area (width), and individual number of long-tailed macaque groups on each observation transect line

Observations indicate that several sizable colonies inhabit coastal fringe areas characterized by abundant vegetation. This behavior might be attributed to the readily available food sources and the added protection afforded by the coastal environment against potential threats. This aligns with observations from the neighboring island, Tinjil Island, where a similar habitat has been noted. The vegetation on Tinjil Island plays a crucial role in sustaining the well-being of LTM. Abundant food resources, particularly staple items like figs, contribute significantly to fulfilling the energy requirements necessary for their survival and reproductive success (Perwitasari-Farajallah et al. 2023).

Our research contributes an assessment of the LTM population density and abundance on Deli Island, which demands further refinement through additional research. Similar studies should be conducted across LTM's entire distribution range in Indonesia to ascertain population size and trends in their native environment. The outcomes of this investigation can also augment the understanding of LTM in Indonesia, facilitating evaluations of their conservation status and management practices in the nation. We hope that the findings from this study can play a role in shaping decisions related to the preservation and conservation of LTM in Indonesia.

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