

Bio-ecology of *Macaca fascicularis* population in Pool Bus area, IPB University

Ahsani Taqwim¹, Azimah Wardahtul Ishlah¹, Heri Setiawan Yunus¹, Puji Rianti^{1*}

¹Department of Biology, Faculty of Mathematics & Natural Sciences, Bogor Agricultural University, Dramaga Campus, Bogor 16880, Indonesia.

Abstract

The long-tailed macaque (*Macaca fascicularis*) belongs to the *Cercopithecidae* family. At IPB University, *M. fascicularis* occupies the pool bus area as one of its habitats. In this study, we observed a total of 19 individuals: two adult males, five adult females, eight juveniles, and four infants. The age structure alone indicates the potential for further population growth. This population thrives due to the abundance of food resources and fresh water in the pool bus area. As frugivores, *M. fascicularis* in this area shows a preference for fruit, with eight out of 12 foods being fruits. They consume star fruit (*Averrhoa carambola*), yellow mombin (*Spondias mombin*), palm fruit (*Elaeis guineensis*), corn (*Zea mays*), banana (*Musa sp.*), papaya (*Carica papaya*), jeluak (*Microcos tomentosa*), and melinjo (*Gnetum gnemon*). Additionally, we found that they use *Parkia timoriana* as their sleeping tree.

Keywords: food preference, human-primate ecosystem, Long-tailed macaque, sleeping tree, urban habitat

1. Introduction

The long-tailed macaque (*Macaca fascicularis*), abbreviated as LTM, belongs to the *Cercopithecidae* family. In Indonesia, regulations permit the captivity and export of *M. fascicularis* under the Minister of Environment and Forestry Regulation Number 26/Kpts-II/94, which covers the utilization of long-tailed macaques and southern pig-tailed macaques (*Macaca nemestrina*). A recent reclassification in 2022 by the International Union for the Conservation of Nature (IUCN) changed *M. fascicularis* status from Vulnerable to Endangered. However, a recent study argued that this classification lacks supporting data and is based solely on expert opinion (Hilborn & Smith 2024). *M. fascicularis* behavior is generally diurnal, with activities including moving (28.4%), foraging (25.2%), resting (19.1%), and grooming (12.3%) (Wong 2019). They begin moving and foraging from their sleeping tree in the morning and return in the afternoon (Sajuthi 2016). Northern pig-tailed macaques (*M. leonina*) choose sleeping sites close to their first or last feeding tree of the day, facilitating access to human food during fruit scarcity due to proximity to human settlements (Albert *et al.* 2011). As opportunistic primates, *M. fascicularis* eat a variety of foods depending on availability and the fruit season (Kamilah *et al.* 2013).

M. fascicularis is primarily distributed across Southeast Asia, spanning from the Indo-Malay region to parts of Indochina. Its range extends across Thailand, Cambodia, Laos, Vietnam, and into Malaysia, Indonesia, and the Philippines,

with populations found on offshore islands such as Sulawesi and Borneo (Fooden 2000; Supriatna and Wahyono 1995). These macaques inhabit a variety of ecosystems, including tropical rainforests, mangrove forests, and urban environments (Zhao *et al.* 2013). The species adaptability to both natural and human-modified habitats has made it one of the most widely distributed primates in Southeast Asia, with notable occurrences in temples, coastal regions, and agricultural areas (Sutrisno *et al.* 2021).

In Indonesia, the long-tailed macaque is widely distributed across several islands, notably Java, Bali, Sumatra, and Sulawesi (van Schaik *et al.* 2004). The country's diverse habitats, including dense tropical forests, coastal mangroves, and urban areas, support the species in a variety of ecological niches (Mittermeier *et al.* 2013). Their presence in both protected regions and human-dominated landscapes highlights their adaptability but also underscores challenges like habitat fragmentation, human-wildlife conflict, and the effects of environmental changes on their populations (Sutrisno and Setiawan 2020).

Several habitat types at IPB University host the *M. fascicularis* population. Located about 9 km west of Bogor City, IPB University spans 257 hectares and falls within Babakan Village, Dramaga District, Bogor Regency, West Java Province. The borders include Babakan Village to the east, Ciapus and Cisdane Rivers to the north, Cihideung River to the west, and Bogor-Jasinga Highway to the south (Mustari 2020). Geographically, it lies between 6° 32' 45" to 6° 33' 45" N and 106° 42' 43" to 106° 44' 15" E (Mustari 2020). A recent study documented 41 *M. fascicularis* individuals across IPB University, including the pool bus area, the LSI Library, lecturer housing, and the Cikabayan deer breeding facility

*Corresponding author

Email Address : pujirianti@apps.ipb.ac.id

(Muchtiarsyah 2019). Another study identified 24 food preferences among *M. fascicularis* across three locations: al-Hurriyah Forest, LSI Lake, and the Pool Bus Bamboo Arboretum Forest, with 22 plant species and the remainder insects (Ritonga 2021). Research into the feeding habits of these macaques identified 24 different food types across three key locations: al-Hurriyah Forest, LSI Lake, and the Pool Bus Bamboo Arboretum Forest. Of these, 22 were plant species, with the remainder being insects (Ritonga, 2021). These findings align with other studies of *M. fascicularis* in similar habitats, highlighting the species's adaptability to a range of environments within urban and semi-urban landscapes. Observations of macaques in comparable settings indicate that their behavior, including food preferences and movement patterns, varies with habitat type and resource availability.

M. fascicularis adapts to various habitat types, even those overlapping with human activities. The growing population at IPB University necessitates regular monitoring of *M. fascicularis* population dynamics and habitat characteristics to manage potential human-macaque conflicts. This study investigates the *M. fascicularis* population structure and habitat characteristics, such as food preferences and sleeping tree of *M. fascicularis* in the pool bus area of IPB University.

2. Materials and Methods

2.1. Study site

The Poolbus area is located in front of the FEM auditorium and covers approximately 6 hectares at IPB University, Dramaga, Bogor, West Java. Its forest ecosystem comprises both abiotic and biotic structures. The biotic component includes a stream that flows through the middle of the Poolbus forest, the Ciapus River as a border, and surrounding residential areas (Fig. 1). Bamboo and rubber trees predominate in the plant community of the Poolbus area. Other notable plants include banana trees, oil palm, star fruit trees, teak, banyan, and yellow mombin.

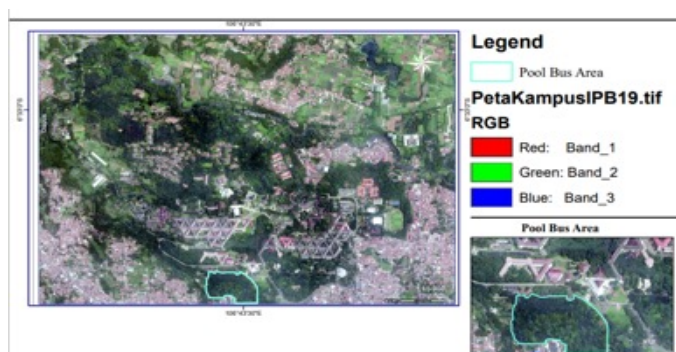


Figure 1. Maps of the Poolbus area inside IPB University, Dramaga, Bogor, West Java (Rectangle green color; Source: Google Earth)

2.2 Data collection

This exploratory study took place in May 2024 at the Poolbus area of IPB University in Dramaga, Bogor. We conducted data collection over four days, from 06:00-18:00h. We used the concentration

count method, which involves focusing on locations with the highest intensity of primate encounters (Bismark 2009). Observers followed *M. fascicularis* movements and recorded coordinates using the Avenza application. We input all encounter coordinates into the Geographic Information System (GIS) software ArcMap 10.8. To determine the number of *M. fascicularis* by sex, we calculated the ratio of male to female individuals. Additionally, we recorded the number of individuals, age class, sex, and the locations of sleeping and feeding trees. We determined the sex of the *M. fascicularis* by examining their genitalia (scrotum for males, nipples for females) (Fitriana *et al.* 2024).

2.3 Data analysis

All encounter coordinate points were entered into the Geographic Information System (GIS) software, ArcMap 10.8. The number of *M. fascicularis* by sex was obtained by calculating the comparison between male and female individuals.

3. Results

3.1 Distribution map of long-tailed macaque day range in the Poolbus area

On the first day of the survey, the *M. fascicularis* group concentrated their movements within a central area covering 1.074 hectares. On the second day, the group expanded their range, moving more widely into the northern and eastern areas, covering 1.240 hectares. On the third day, the *M. fascicularis* group primarily moved to the western area before returning to their sleeping trees, covering 0.776 hectares. On the fourth day, their movements extended into both the northern and southern areas, covering 1.071 hectares (see Fig. 2).

3.2 Population structure

We observed a total of 19 *M. fascicularis* individuals in the Poolbus area. We identified adult *M. fascicularis* by their genitalia, recording two males and five females, with four of the females carrying infants. We identified juveniles by their black mohawk-like hair, noting eight individuals (Fig. 3a). Additionally, the sex ratio in the Poolbus area for males and females is 2:5 (Fig. 3).

3.3 Food preferences of *Macaca fascicularis* in the Poolbus area of the IPB Dramaga campus

M. fascicularis consumes various types of food plants, including star fruit, yellow mombin, palm fruit, rubber seeds, bamboo, corn, ketapang, banana, papaya, jeluak fruit, melinjo fruit, and banyan (see Table 1). They eat different parts of these plants, such as fruits, seeds, leaf shoots, and leaves. Fruits constitute the dominant part of their diet. Among the foods consumed, bamboo leaf shoots and rubber seeds are consumed most frequently. This preference results from the abundant availability of these plants and their proximity to sleeping trees. Palm fruit and star fruit also show high consumption frequencies due

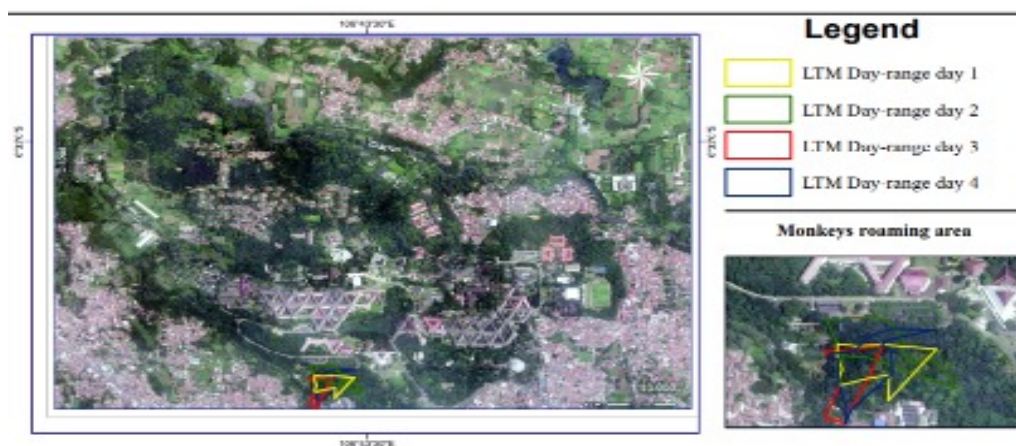


Figure 2. Day-range long-tailed macaques in the Poolbus area of IPB University. Each rectangle shows the day range of the *M. fascicularis* troop.

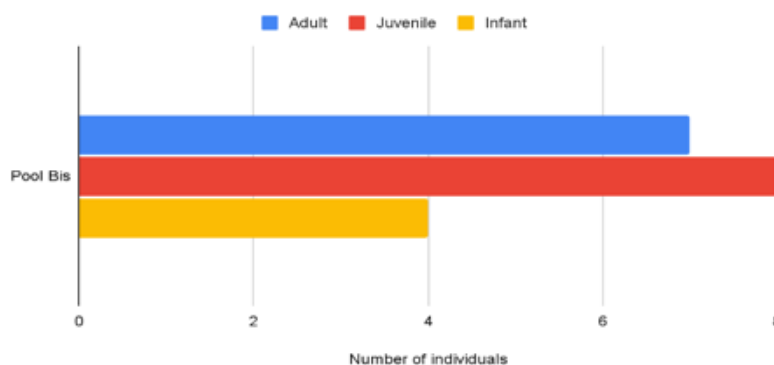


Figure 3. Number of *Macaca fascicularis* individuals across age structure and sex ratio. Number of individuals per age structure observed.

to their abundance in the Poolbus area during the fruiting season.

3.4 Sleeping tree of *Macaca fascicularis* in the Poolbus area of the IPB Dramaga campus

Over four days, we observed that *M. fascicularis* consistently slept in a specific tree, *Parkia timoriana* (see Fig. 4). We identified the sleeping tree at dawn, when *M. fascicularis* climbed to the top of the tree. This tree species stands 18 meters tall with a diameter of 19.20 cm.

Table 1. Food tree species of *M.fascicularis* in the Poolbus area at IPB Dramaga campus

No.	Local name	Scientific name	Part of eaten
1	Star fruit	<i>Averrhoa carambola</i>	Fruit
2	Yellow mombin	<i>Spondias mombin</i>	Fruit
3	Palm Fruit	<i>Elaeis guineensis</i>	Fruit
4	Rubber seeds	<i>Hevea brasiliensis</i>	Seed, leaf shoots
5	Bamboo	<i>Bambusa sp.</i>	Leaf shoots, leaves
6	Corn	<i>Zea mays</i>	Fruit
7	Ketapang	<i>Teriminalia catappa</i>	Leafshoots
8	Banana	<i>Musa sp.</i>	Fruit
9	Papaya	<i>Carica papaya</i>	Fruit
10	Jeluak fruit	<i>Microcos tomentosa</i>	Fruit
11	Melingo fruit	<i>Gnetum gnemon</i>	Fruit
12	Banyan	<i>ficus benjamina</i>	Leaf shoots

During the four-day observation period, *Parkia timoriana* was recorded as a sleeping tree used by *M. fascicularis*. It is located near a stream and close to food sources such as palm, bamboo, and rubber trees. The tree’s height of 18 meters, combined with the abundance of bamboo and rubber trees growing around it, provides excellent concealment. The tree’s morphology makes it an ideal sleeping tree, protecting *M. fascicularis* from human activity.

4. Discussion

The Poolbus area, a 6-hectare arboretum at IPB University in Dramaga, Bogor, West Java, serves as a habitat for a group of *M. fascicularis*. *M. fascicularis* were introduced to IPB; however, the specific agent responsible for their introduction is not documented—University around 1990. Previous studies recorded four individuals in 2019, which increased to 10 individuals within two years (Mughtiarsyah 2019; Ritonga *et al.* 2021). Our study indicates that the *M. fascicularis* population in the Poolbus area continues to grow, as evidenced by the higher number of young individuals compared to adults (Santosa *et al.* 2008; Egeustin *et al.* 2023).

The increase in *M. fascicularis* population structure is influenced by the abundance of food plants and other resources. The absence of predators and competitors allows *M. fascicularis* to remain at



Figure 4. Sleeping tree of *Macaca fascicularis*, *Parkia timoriana*.

Table 2. Nutrient content analysis of *Macaca fascicularis* diet

No	Feed type	Moisture (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	References
1	Star Fruit	85,1	72,2	4,0	11,7	8,6	3,50	Edem <i>et al.</i> (2008)
2	Yellow mombin	83,66	13,90	1,06	0,62	1,87	0,76	Tiburski <i>et al.</i> (2011)
3	Palm fruit	-	-	9,22	3,34	31,09	4,48	Sundram <i>et al.</i> (2003)
4	Rubber seeds	9,1	15,9	27	32,3	-	3,96	ly <i>et al.</i> (2001)
5	Bamboo leaf	-	-	15,09	1,43	23,15	18,03	Attaya (2009)
6	Corn	11,03	71,3	3,7	1,0	86,7	0,8	Inglett (1987) dalam Suarni (2011)
7	Ketapang seed	5,24	5,8	22,63	-	6,81	-	Darmawan (2016)
8	Banana	75,3	23	0,74	0,29	1,7	0,7	USDA Nutrient Database (2019)
9	Papaya	86,6	12,1	0,5	0,3	0,7	0,5	USDA Nutrient Database (2022)
10	Melinjo fruit	72,6	13,3	5,2	2,1	5,2	1,8	CABI (2019)
11	Banyan	-	-	6,67	2,68	36,24	6,46	Kassim <i>et al.</i> (2017)

the top of the food chain, promoting continuous population growth (Atmoko 2011). The abundance of vegetation provides ample food sources, and the stream supplies fresh water for the *M. fascicularis*. Previous studies have identified *M. fascicularis* as a frugivorous animal, with fruits comprising 74.22% of its diet (Farida 2008). Our observations corroborate this, with 8 out of 12 plant species consumed being fruits (67%), followed by leaf shoots.

Food is a crucial energy resource for *M. fascicularis*, derived from plants, insects, and fungi. The nutrients in their diet play a vital role in maintaining their health and supporting their activities. Protein, fiber, and fat levels required by *M. fascicularis* are 8.00%, 2.00-8.00%, and 5.00-9.00%, respectively, for bone and muscle maintenance. Vitamins A and D are essential for healthy bones, teeth, and eyes, with required levels of 10,000.00-15,000.00 IU/kg and 2,000.00-9,000.00 IU/kg, respectively. Niacin, thiamin, and riboflavin, necessary for healthy skin, nerves, and the digestive system, are required at levels of 50.00-110.00 mg/kg, 15.00-30.00 mg/kg, and 25.00-30.00 mg/kg, respectively (National Research Council 2003).

In the Poolbus area, *M. fascicularis* consumes 12 types of food, including star fruit, yellow mombin,

palm fruit, rubber seeds, bamboo leaves, corn, ketapang seeds, papaya, jeluak fruit, and melinjo fruit. This type of food contrasts with previous research, which identified eight types of food consumed in the Poolbus area, including star fruit, rubber seeds, banyan, bamboo, grass, breech fig, African wood, and trembesi (Ritonga 2021). Changes in the home range of *M. fascicularis* can occur due to fluctuations in food availability, causing *M. fascicularis* to expand its range in search of better and more abundant food sources (Quinda *et al.* 2013).

Food sources are essential to the dietary needs of *M. fascicularis*, providing necessary nutrients such as moisture, carbohydrates, fats, proteins, fiber, and ash (Table 2). Among the available feeds, yellow mombin stands out with a high moisture content of 83.66 g and an energy value of 65.42 kcal. It is a crucial food source for the macaques, supporting their energy needs for activities like moving, playing, and exploring (Tiburski *et al.* 2011). Yellow mombin also has an appealing taste and attractive color, similar to star fruit.

Star fruit (*Averrhoa carambola*) is a prominent food plant in the Poolbus area of the IPB Dramaga campus. *M. fascicularis* often consumes the fruit,

favoring it for its smell, color, and weight (Musfaidah *et al.* 2019). Star fruit, with its striking color, high water content, and vitamin C, serves as a nutritious option. According to the USDA Nutrient Database (2010), star fruit contains 34.4 mg of vitamin C, which supports the nutritional needs of *M. fascicularis*.

Palm fruit (*Elaeis guineensis*) is another favored food of *M. fascicularis*. This fruit features a mesocarp layer with high fiber content (Table 2). Palm oil trees, widely found on the IPB campus, are invasive species that spread quickly and cover large areas, facilitated by wildlife such as the plantain squirrel (*Callosciurus notatus*). Oil palms reproduce effortlessly and are tolerant of environmental stress, such as acidic soil conditions in their youth, though they become less tolerant as they mature (Pahan 2008).

Food not only nutritional needs but also influences the selection of sleeping trees for *M. fascicularis*. After descending from their sleeping tree in the morning, *M. fascicularis* engage primarily in foraging, which constitutes 43.45% of their daily behavior (Suwanto 2014; Rizaldy *et al.* 2016). This behavior leads *M. fascicularis* to choose sleeping trees based on proximity to food plants. Besides food availability, *M. fascicularis* selects sleeping trees based on water sources, crown area, and tree height (Setiawan *et al.* 2013).

Parkia timoriana, also known as kedawung, belongs to the Fabaceae family. It features dense and wide crowns, smooth gray-green bark, and ovoid seeds. This tree, standing at 18 meters tall, falls within the adult height range of 15-25 meters (Rugayah *et al.* 2014). The kedawung tree's tight and wide canopy provides *M. fascicularis* with comfort and protection from predators. Other primates, such as proboscis monkeys, golden-backed uacaris, and gibbons, also select trees from the Fabaceae family as sleeping sites (Bernard *et al.* 2011; Barnett *et al.* 2012; Harrison *et al.* 2021).

A suitable sleeping tree protects primates from predators, falls, or attacks from other groups during the night (Fruth *et al.* 2018). During our observations, the *M. fascicularis* group consistently used the same sleeping tree. This behavior contrasts with that of Celebes crested macaques (*M. nigra*), which tend to use different sleeping sites consecutively due to predator encounters (Qomariah *et al.* 2023). We did not observe any suspected predators. *M. fascicularis* does not show a particular preference for specific tree species, choosing tall trees similar in size to others nearby (Brotcorne *et al.* 2014; Setiawan, 2018). In mangrove forest habitats, *M. fascicularis* use *A. officinalis* and *R. apiculata*, which are 16-20 meters high, as their sleeping trees (Baihaqi *et al.* 2017). Qomariah *et al.* (2023) found that *M. nigra*'s sleeping trees are typically close to feeding trees, with distances ranging from 0 to 488 meters. Our study recorded sleeping trees within 0-200 meters of feeding trees.

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