Distribution of long-tailed macaque (*Macaca fascicularis*) in Kelimutu National Park

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Abstract. Long-tailed macaques (*Macaca fascicularis*) are one of the mammals that live in Kelimutu National Park (Kelimutu NP). This mammal, in its natural habitat, has an impact on buffer zones in the form of animal activities that damage crops on plantation lands. The purpose of this study was to identify the distribution of long-tailed macaque populations. This research was conducted in August 2010 by covering areas within the region and outside the Kelimutu NP area. Data analysis was used to calculate the abundance index, the encounter rate for estimating abundance and distribution based on the length of the track surveyed. The results indicated that the distribution of long-tailed macaques populations in Kelimutu NP was most widely found in field habitats, with a relatively low abundance of around five individuals/km. Based on the calculation of habitat carrying capacity for groups of long-tailed macaque in the tourism zones, it is still below the maximum limit. The increased awareness of ecological insight tourism also needs to be optimized related to the presence of long-tailed macaque in the tourism zones of Kelimutu NP. Development of habitats, such as planting of trees for foods and protected zones is necessary to provide a suitable habitat for long-tailed macaque.

1. Introduction

*Macaca fascicularis* (long-tailed macaques) has a wide distribution area in Southeast Asia [1,2]. This primate belongs to the old world monkey category in the Cercopithecidae family. Long-tailed macaque has been categorized again in the Cercopithecinae subfamily associated with food adaptation. Primates in this subfamily are characterized by low molars, have cheek pockets to store food for a short time, and fruits are part of the diet [3].
Long-tailed macaque began migrating to the Indonesian archipelago from mainland Asia approximately 18,000 thousand years ago when sea levels were 120 meters lower than they are now [4]. *Macaca fascicularis* has ten sub-types spread throughout Asia, especially Southeast Asia. *Macaca fascicularis* is a sub-type found in Brunei, Cambodia, Indonesia (Sumatra, Java, Kalimantan, Bali, Lombok, Sumbawa, Flores, Sumba, and Timor), Malaysia, the Philippines, Singapore, Southern Thailand and southern Vietnam [5].

The Kelimutu National Park (Kelimutu NP) is one of the smallest national parks in Indonesia. Kelimutu NP has an area of 5,356.5 hectares. However, it has high biodiversity on Flores Island. At least 70 species of fauna have been found in Kelimutu NP, one of which is long-tailed macaques. Kelimutu NP on Flores Island is one of the latest distributions of long-tailed macaque in the Lesser Sunda region, which includes Bali, Lombok, West Nusa Tenggara, and East Nusa Tenggara. The seas in the Lesser Sunda region and nearby islands 18,000 years ago receded more than 120 meters compared to now, and it was then possible that the long-tailed macaque migrated from the Sunda Islands (Java, Sumatra, and Kalimantan) [4]. Long-tailed macaque can still survive and breed on the island of Flores, including in the Kelimutu NP, until now. Local communities call Ro’a for this primate [6]. Research on long-tailed macaque in this region is still minimal, and reports of research activities in the Kelimutu NP related to long-tailed macaque can be found in the utilization zone and jungle zone.

There are no scientific documents related to the status of long-tailed macaques in the Lesser Sunda area, especially in the conservation area, which is famous for its three-color lakes. Their current conditions in the Kelimutu Lakes, monkey area, are often seen looking for leftover food from visitors in the trash. The potential as an additional tourist attraction is also done by making feeding grounds as a place to feed long-tailed macaque. As in many places in Indonesia, this monkey does contribute to the development of tourism [7–9]. Feeding monkeys in several places in Indonesia is an additional tourist attraction. Attractions from these tours can give tourists a longer time so that tourists who stay longer to see tourist attractions can provide added value in terms of economic value for the surrounding community. Despite its positive potential, long-tailed macaques at tourist sites also have potential problems, human and primate conflicts, aggressiveness, behavioral changes, and zoonotic potential (transmission of diseases from humans to animals and vice versa) [10]. Therefore, this study was conducted to provide basic information about long-tailed macaque in the Kelimutu NP. As one of the potential wildlife in conservation areas, information on population status, distribution, and habitat are very important as a basis for wildlife management.

2. Method
This research was conducted in August 2010, covering areas within and outside the Kelimutu NP area. This research used a descriptive method with a quantitative approach. Several techniques were used to determine the distribution of long-tailed macaque populations. The first thing to do was to gather necessary information about the existence of long-tailed macaque from the surrounding community. Gathering long-tailed macaques information related to the location of the encounter, the number of groups, the estimated number of individuals per group, and information regarding the existence of these animals as pests for community plants. Furthermore, the team conducted a field survey based on the information obtained. The survey was conducted by visiting places suspected of being long-tailed macaque doing activities. By considering the mountainous geographical conditions, existing routes were used for general review to get an initial picture of the population and distribution of long-tailed macaque, by calculating an abundance index. The encounter rate was used to estimate abundance and distribution based on the length of the road surveyed or the time used for the survey (Figure 1) [11].
Figure 1. Survey methods of long-tailed macaque distribution.

A more detailed survey of the population was focused on the tourism area of the Kelimutu Lakes, where long-tailed macaque here has also begun to be habituated with humans, and there are locations for feeding at certain times. The principle of line transect was applied to estimate the density of long-tailed macaque around Kelimutu Lakes (Figure 2) [12,13]. This method was used based on direct encounters with long-tailed macaque by estimating the maximum distance between groups of long-tailed macaque and the transect line. Each encounter with a long-tailed macaque, some information such location, GPS coordinates, number of individuals, estimated distance perpendicular to the transects, and the width of the transect was recorded.

Direct count using a hand counter was done in the feeding area. Members of the population were grouped into classes of adult, juvenile, and infants [16]. Although it takes habituation time to recognize the character of individuals in the group, in general, the male long-tailed macaque is
characterized by faces with less dense whiskers, mustaches, left and right sitting pads together, and the presence of scrotum. Male long-tailed macaques are grouped into adult males when their bodies are large, their fangs are long, and their behavior is relatively superior. Female long-tailed macaques are characterized by faces with dense beards, beards, separate left and right sitting pads, and the presence of a vaginal vulva. Female long-tailed macaques are grouped into adult females when their udders and nipples have hung (pendulous). In the group of juveniles, the sexes were not differentiated. They are joined together because of the difficulty of distinguishing them. Male long-tailed macaques are classified as juvenile long-tailed macaques if their bodies are smaller, and their behavior is permissive to adult males present at the time. While females long-tailed macaques are classified as juvenile long-tailed macaque if they do not have hanging nipples yet. The lower age limit for teenage long-tailed macaques is that the color of their black hair on the head has changed into grey. Meanwhile, newborn long-tailed macaque, which still has black hair on the head, is classified as infant and often closer to the parent [7, 17]. The number of each group member was combined into one local population data. The calculation began from adulthood, adolescents, then infants, and depended on the conditions in the field at the time., It was done with several repetitions for more convenience.

![Figure 2. Line transect method [10,14,15].](image)

Distribution survey data analysis used mapping software, including the GPS points of the long-tailed macaque encountered on the map. Data analysis to estimate the density of long-tailed macaque around Kelimutu Lakes used the line transects method and the following formula:

\[
\text{Density} = \frac{\text{Number of individuals}}{\text{Area}}
\]

(1)

\[
= \frac{\text{Number of individuals}}{(\text{Length of transect} \times \text{width} \times 2)}
\]

(2)

\[
= \frac{\text{Number of individuals}}{(L \times W \times 2)}
\]

(3)

3. Results and discussion
This research conducted a path survey of ± 67.7 km (Table 1). There were 15 groups found, so the value of the encounter rate was 0.22 groups. If the average number of individuals per group is 22.66
individuals (range of 5-50 individuals), then approximately five individuals can be found in each kilometer.

**Table 1.** Length of survey path and encounter with long-tailed macaque.

| Location                                      | Length of Path Way (km) | Number of Groups |
|-----------------------------------------------|-------------------------|------------------|
| Gate of Kelimutu NP - Kelimutu Lakes          | 4.37                    | 2                |
| Kurulimbu - Puutuga                           | 4.71                    | 2                |
| Mbuja - Detuboka                               | 2.18                    | 2                |
| Mbuja - wiwipemo                              | 1                       | 1                |
| Manukako                                      | 1.5                     | 3                |
| Niowula                                       | 2                       | 3                |
| Saga- Kurulimbu                               | 51.61                   | 2                |
| **Total**                                     | **67.37**               | **15**           |

Steep topography is the main obstacle to cover all locations. The route from Saga to Kurulimbu is the main road transportation through the national park area, which long-tailed macaque is reportedly often seen along the road. The survey on that route used a car, and other locations of the survey were reached on foot.

**Figure 3.** The distribution of long-tailed macaques in various types of habitats
Figure 4. Habitat of primary forest in Detuboka hills.

Figure 5. Habitat condition of Long-Tailed macaques in Kurulimbu.

Table 2. The survey results of the long-tailed macaque distribution in the Kelimutu NP.

| No | Date       | Location                        | Coordinate  | Elevation | Number of Groups | Habitat                  | Information   |
|----|------------|---------------------------------|-------------|-----------|------------------|--------------------------|---------------|
| 1  | 16 August 2010 | Saga                            | 08°46’45.5" | 121°44’40.0" | 1086             | 12 Shrubs                | pest attack   |
| 2  | 18 August 2010 | Mbuja                           | 08°48’20.7" | 121°49’48.5" | 890              | 15 Field                 | pest attack   |
| 3  | 18 August 2010 | Kelimutu km 9                   | 08°46’17.0" | 121°49’53.3" | 1269             | 13 Secondary forest      | pest attack   |
| 4  | 19 August 2010 | Bukit Detuboka Mboja Wolokelo   | 08°47’48.3" | 121°49’38.7" | 1401             | 7 Primary forest -       |               |
| 5  | 19 August 2010 | Mboja                           | 8°44’19.7"  | 121°50’01.1" | 1049             | 50 Field                 | pest attack   |
| 6  | 19 August 2010 | Manukako, Ae Gera               | 8°45’46.8"  | 121°49’59.0" | 1173             | 30 Shrubs                | pest attack   |
| 7  | 19 August 2010 | Manukako, Ae Kela               | 8°45’43.5"  | 121°49’47.7" | 1174             | 20 Secondary forest      | pest attack   |
| 8  | 19 August 2010 | Manukako, Ae Gara               | 8°45’54.2"  | 121°50’04.9" | 1182             | 25 Field                 | pest attack   |
| 9  | 21 August 2010 | Feeding ground Kelimutu Lakes   | 8°46’06.5"  | 121°48’45.9" | 1584             | 47 Shrubs                | -             |
| 10 | 23 August 2010 | Niowula                         | 8°44’52.3"  | 121°44’41.7" | 856              | 25 Field                 | pest attack   |
| 11 | 23 August 2010 | Kurulimbu                       | 08°48’51.9" | 121°43’30.8" | 754              | 23 Shrubs                | pest attack   |
| 12 | 23 August 2010 | Saga 2                          | 8°47’03.6"  | 121°45’24.4" | 1238             | 5 Shrubs                 | pest attack   |
Direct encounters with long-tailed macaque showed that they were commonly found in the fields and shrub habitats (Table 2). Even though the number of individuals found in the habitat was higher, the average number of individuals found in both habitats was almost the same (Figure 3). It is due to the typical types of a long-tailed macaque whose habitat is close to humans [3,16,17]. The encounter that occurred during the observation was found on the edges of the forest/ boundary area, where the area is bordered by people's fields. Only two long-tailed macaques were found foraging in the primary forest of the Detuboka Mbuja hill region. There were fewer groups found in forest/natural habitat than the number of individuals in groups found in fields or shrubs (Figures 4-7). However, it does not describe their preferred habitat because how long these long-tailed macaques use the habitat was not included as a parameter.

**Figure 6.** Habitat in Wiwipemo and surrounding areas (the border between fields and shrubs in Kelimutu NP area).

**Figure 7.** Long-tailed macaques around Kelimutu Lakes.

Distribution of long-tailed macaques was known at an altitude of 1.100 – 1.300 meters above sea level (ASL). However, there are also groups with nearly 50 individuals found at an elevation of 1.500 m above sea level, namely in the feeding ground area around Kelimutu Lakes (Figure 8). Natural foods commonly eaten by long-tailed macaques and found in the high altitude are plants, small animals (insects and earthworms), fungi, and water from lakes [18]. Mountainous geographical conditions and habitats that have various degrees of height make it possible to spread the long-tailed macaques unevenly. It means that there are certain types of favorite habitat. If the survey also includes forest areas on the coast, which might also be used by long-tailed macaques, it will provide a clearer picture [1].

More detailed population calculations were carried out on groups of long-tailed macaques that were often located in the peak of Kelimutu Mt. This group has been accustomed to and interacted with visitors of Kelimutu Lakes. According to information from national park officials, two groups are often found in the tourist area of Kelimutu Lakes. The calculation Table 3 is only one large group, but the smaller groups did not appear when observations were made. Long-tailed macaques have very high social interactions between individuals in groups. They also tend to hunt for food in groups [19–21].

The estimated population density around Kelimutu Lakes was based on transect lines starting from Post Moni to the peak of Kelimutu Mt. In the 4.37 km line transect, two groups of long-tailed macaques were found. If equation 4 is used, the density that will be obtained is 4.57 groups / km².
When we used the average number per group encountered in the entire Kelimutu NP area is 22.66 individuals, in every kilometers squares there are approximately 104 individuals. Although the conditions of each monkey habitat varied, the relative density of long-tailed macaques were still below the maximum carrying capacity in nature that can accommodate up to 300 individuals/km$^2$, without additional feed [15, 22]. The mean number of individuals indicated that the natural condition/carrying capacity of natural food was still sufficient for the long-tailed macaques to breed around the Kelimutu Lakes. These conditions make the existence of long-tailed macaques able to survive with existing natural food. Under certain conditions, feeding outside can be done as habitat development due to the lack of natural food availability in the wild and unique purposes such as captivity in nature. Although there are no data on the availability and types of natural food sources of long-tailed macaques around Kelimutu Lakes, $Ficus$ sp. is one type of natural food found around Kelimutu Lakes (Figure 9 and 10).

Figure 8. The distribution of long-tailed macaques in various elevations.

Table 3. Long-tailed macaque population encountered around Kelimutu Lakes.

| Repeat | Total | Male Adult | Female Adult | Juvenile | Infant |
|--------|-------|------------|--------------|----------|--------|
| 1      | 42    | 11         | 14           | 16       | 1      |
| 2      | 38    | 5          | 8            | 23       | 2      |
| 3      | 40    | 15         | 14           | 9        | 2      |
| 4      | 47    | 11         | 15           | 19       | 2      |
| Mean ± Standard Deviation | 41.75±3.86 | 10.50±4.12 | 12.75±3.20 | 16.75±5.91 | 1.75±0.50 |

The availability of various feeds will also affect the movement of long-tailed macaques. Tourism activities, such as the behavior of visitors who are attracted to long-tailed macaques and feed them, also have an impact on the behavior of long-tailed macaques [21,23]. It certainly will also affect the ecological behavior of the long-tailed macaques to be more opportunists to find food easier, such as foraging in the trash (Figure 11).
Nature tourism activities that exclude ecological factors are very likely to disturb the behavior and biological balance of long-tailed macaques [9, 24, 25]. Rapid population growth, over habituation, and hyper aggressiveness can become severe problems in the future. Furthermore, habitats also experience changes or even disappear [8, 26]. It cannot be denied that the relationship between primates in tourism objects can also be commensalisms, such as the economic impact, education, and population protection. The basis of complete research on population, behavior, and group distribution will be essential for the management or use of long-tailed macaques as one of the potential tourist attractions. Strict regulations for visitors to interact with animals and good ranger capacity for interpretation can optimize interactions between long-tailed macaques and humans. However, the conflict will also arise when the interaction is no longer balanced. Conflicts such as the potential for disease transmission, physiological distortion of long-tailed macaques, and the availability of natural food can occur [8, 27]. Anthropogenic supplementary feeding needs to be considered. Supplementary feeding with high carbohydrates will cause an increase or even decrease in birth rates that are relatively different from normative patterns, body size changes, and length of life may also be disrupted [28, 29].
4. Conclusion
The distribution of the long-tailed macaques' population in the Kelimutu NP was mostly found in the field habitat. The population abundance was still low, which was around five individuals/km. Nevertheless, it is still possible for these movements to be seasonal, and the movements of individual groups may also be different from the present. Population density will differ from a variety of locations related to habitat, food availability, predators, and others. Based on the calculation of habitat carrying capacity for groups of long-tailed macaques in the tourism zones, it was still below the maximum limit. Increased awareness of ecological tourism insight also needs to be optimized related to the presence of long-tailed macaques in the tourism zones of Kelimutu NP. The development of habitats, such as planting trees for foods and protected zones, is necessary so that suitable habitat for long-tailed macaques can be provided.

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