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**Research Article**

# The Distribution and Abundance of Long-Tailed Macaques in the Main Campus of Universiti Malaysia Sabah and its Vicinity

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**Abstract**
Long-tailed macaques (*Macaca fascicularis*) inhabit a wide range of natural and human-modified environments in Southeast Asia. Because of their ability to occupy the same space and utilise the same food resources as humans, long-tailed macaques have in some cases been regarded as nuisance and pest. As part of an effort to assess the status of human-macaque interactions in the main campus of Universiti Malaysia Sabah (UMS), we conducted a survey to determine the distribution range and estimate the abundance of the macaque population. We performed the survey monthly from April 2019 to March 2020 at 13 localities classified into three different habitat types i.e. secondary forest, forest edge and urban areas identified in the campus and its vicinity. The survey covered an overall area of 6.02 km$^2$. We recorded the group or individual locations and the number of macaques with each individual's age/sex information whenever possible. The macaques consisted of three different multimale-multifemale groups and a solitary individual. We recorded a minimum population size of 54 macaque individuals with an average group size of 17.7 individuals and a population density of 8.97 individuals/km$^2$ in the surveyed areas. Macaques were encountered every month and in all habitat types defined in this study. However, they were mainly distributed at two habitat types i.e. urban areas and forest edges near Bukit UMS and the student residential colleges where anthropogenic influence appeared to be high. We speculate that the monthly availability of food resources, including anthropogenic food waste, may partly explain this distribution pattern. We suggest that further studies is conducted in this regard.

**Keywords:** *Macaca fascicularis*, distribution, abundance, management implications, human-macaque interactions, Universiti Malaysia Sabah.

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## Introduction

Human-wildlife interactions are a growing concern worldwide (Dickman, 2010; Distefano, 2005; Soulsbury & White, 2016). To effectively manage the interactions, accurate knowledge on the distribution range and abundance of the animals is crucial (Dickman, 2010; Greggor et al., 2016; Redpath et al., 2013; Swan et al., 2017).

Across Southeast Asia's mainland and islands, the long-tailed macaque, *Macaca fascicularis*, is considered one of the most successful species of primates as they are widely distributed (Abegg & Thierry, 2002). Based on Mittermeier et al. (2013) and an updated checklist published in Roos et al. (2014), the species can be found in present-day Bangladesh, Myanmar, Laos, Thailand, Vietnam, Cambodia, Philippines, Malaysia, Singapore, Brunei, Indonesia and Nicobar Islands of India. There are currently at least 10 recognised subspecies, including *M. f. aureus* (Geoffroy, 1831), *M. f. philippinensis* (Geoffroy, 1843), *M. f. tua* (Kellogg, 1944), *M. f. atriceps* (Kloss, 1919), *M. f. condorensis* (Kloss, 1926), *M. f. lasiae* (Lyon, 1916), *M. f. umbrosus* (Miller, 1902), *M. f. fuscus* (Miller, 1903), *M. f. fascicularis* (Raffles, 1821) and *M. f. karimondjawae* (Sody, 1949).

In Malaysia, long-tailed macaques have been reported in Peninsular Malaysia and the states of Sabah and Sarawak on Borneo Island (Roos et al., 2014). Similar to the distribution reported in India, Indonesia, Mauritius, Singapore and Thailand, they are commonly found in riparian zones, coastal forests, mangrove forests, low elevation secondary forests, forest periphery near villages, agricultural plantations and urban/suburban areas, including recreational parks and other tourist attractions (Eudey, 2008; Fooden, 1995; Fuentes et al., 2011; Gumert, 2011; Gumert et al., 2011; Gumert et al., 2012; Hambali et al., 2012; Hansen et al., 2019; Jamhuri et al., 2018; Kurland, 1973; Malaivijitnond & Hamada, 2008; Otani et al., 2020; PERHILITAN, 2018; Riley et al., 2015; Saaban et al., 2014; Sha et al., 2009; Southwick & Cadigan, 1972; Sussman & Tattersall, 1986; Tee et al., 2019; Umapathy et al., 2003). This is most likely due to the availability and easy access to resources, especially food provisioning by humans, whether directly or indirectly, that leads to adaptation and adjustment of their behaviour to live near anthropogenic influences and, hence, interaction with humans. Indeed, on a larger scale in Peninsular Malaysia, 56,786 complaints or 66% of all reported human-wildlife conflict complaints from 2006 to 2015 involved long-tailed macaques (Saaban et al., 2016). Similarly, in 2016, the long-tailed macaque was the most

reported species, with 4,237 complaints or 63% of 6,769 complaints recorded (DWNP, 2016).

Small scale studies have been conducted on some populations in urban areas, particularly university campuses and nature parks in Peninsular Malaysia. Findings reported nuisance behaviour such as foraging at waste areas, littering, entering buildings and displaying aggression towards humans (Hambali et al., 2012; Md-Zain et al., 2011). To manage these issues, the Department of Wildlife and National Parks (DWNP) in Peninsular Malaysia have used various approaches, including culling and trapping of individual macaques (DWNP, 2016; Lappan & Ruppert, 2019; Saaban et al., 2016). Campaigns and awareness programs were also launched, resulting in the setting up of educational signages to improve public education about macaque behaviour, the introduction of macaque-proof bins and the development of manuals and action plans for managing human-macaque conflicts (Saaban et al., 2016). However, these actions' effectiveness, impacts and sustainability on managing human-macaque conflicts, in the long run, are unknown and will urgently require further assessments. Given the increasing proximity of the long-tailed macaque populations to anthropogenic activities and environments, this species is expected to remain among the top most reported species in human-wildlife conflicts in Malaysia in the future.

Long-tailed macaques inhabiting the Universiti Malaysia Sabah's (UMS) main campus are no exception; students and staff have complained reported to the student councils and the UMS management, particularly the management of student residence, regarding the nuisance behaviour of macaques. To date, however, there are no comprehensive studies conducted on the long-tailed macaque population in the campus and its vicinity. Therefore, the present study was conducted to determine the distribution range and estimate the abundance of the macaque population as an initial effort to assess the status of human-macaque interactions in and around the campus area. In this article, we report the long-tailed macaque distribution and abundance.

## Methodology

*Study Area*

Our study area is located at Sepanggar Bay in Kota Kinabalu, Sabah, Malaysia (Figure 1). For nearly three decades until the present time, the bay has been developed as part of an urban expansion of the metropolitan area of Kota Kinabalu. Some of the most notable landmarks include the main campus of

Universiti Malaysia Sabah (UMS), Sabah Federal Government Administrative Complex, Sabah State Legislative Assembly building, residential areas and various supporting infrastructure.

Our main survey sites were located at the centre of Sepanggar Bay, where the main campus of UMS (6.036276°, 116.115700°) was established in 1999. The study covered a total area of 6.02km$^2$, with 4.22 km$^2$ inside the border of UMS campus, whereas the remaining 1.80 km$^2$ is outside of the campus area (Figure 1). Secondary forest, coastal forest, forest edge, residential and commercial buildings, roads and other urban structures make up the general landscape of the study site (Figure 2). Most of the infrastructural development took place in the southern and eastern parts of the campus. In contrast, the northern part consists of an isolated secondary forest fragment occupying the Outdoor Development Centre (ODEC) (6.042845°, 116.112109°) near the coast and the highest peak, Bukit UMS (6.042426°, 116.119485°) at 205m a.s.l.


**Figure 1.** Map of study area and study site in the main campus of UMS and its vicinity, Sepanggar Bay, Kota Kinabalu, where 4.22km$^2$ of the study site is in the shaded part bordered with the white line while 1.80km$^2$ is the shaded part next to it (Google Earth, 2020).

This study defined secondary forest as a continuous area of secondary vegetation, including some planted tree species. We defined forest edges as strips of vegetation that border the secondary forest between 50 – 100m in width, whereas urban areas were defined as built environments contiguous with the forest edges for human settlements and other activities. Based on secondary information on localities where macaques were frequently encountered in UMS, these areas were further divided into 13 localities to be surveyed for long-tailed macaques (Figure 2). These localities were Forest Zone 1 (FZ1), Forest Zone 2 (FZ2) and Forest Zone 3 (FZ3), representing the secondary forest habitat type. Edge Zone 1 (EZ1), Edge Zone 2 (EZ2) and Edge Zone 3 (EZ3) represented the forest edge habitat type, while Kolej Kediaman Excellent (KKE), Kolej Kediaman Tun Fuad (KKTF), Kolej Kediaman Tun Mustapha (KKTM), Institute for Tropical Biology and Conservation (ITBC), Chancellery, Jalan Samudera and non-UMS areas represented the urban area habitat type.

*Data Collection*

We used the general physical characteristics and age-sex classification of long-tailed macaque described by Fooden (1995; 1997) and Poirier & Smith (1974) to identify the individual macaques and distinguish the different macaque groups in this study (Table 1).

Systematic surveys were conducted monthly from April 2019 to March 2020 by walking along existing trails and other pathways at the 13 localities in the secondary forest, forest edge and urban areas. Long-tailed macaques were detected using direct sighting, vocalisation, movement sound or the presence of their faeces or food waste on the ground. When a group or an individual macaque was sighted, we (YYZ and assistant) recorded the location coordinates using a handheld GPS receiver. The number of visible individuals were counted, aided by a pair of binoculars and followed as much as possible to identify the group-type or solitary individual. To assist in group recognition, the key individuals were noted for their unique features. Other distinguishing characteristics of the group, such as the number of mothers with an infant, were also noted. The age-sex class of each individual was identified if possible; otherwise, they were marked as unknown. The group type was recorded as either multimale-multifemale group or all-male group. Observations of a single adult male individual were categorised as solitary male. In addition, other opportunistic observations of macaque groups or individuals outside of the monthly systematic surveys were also recorded, including secondary sightings by UMS students and staff.

**Table 1.** Morphological traits of each age-sex class for the identification of *Macaca fascicularis*.

| Age-sex class | Morphological traits for identification |
|---|---|
| Adult male | Adult male has long and narrow rostrum, large canine, fully developed scrotum and descended testicles. Compared to adult female, length of pelage is longer and body size is bigger. Length of head, body and skull are also greater. |
| Adult female | Adult female has shorter pelage and smaller body size. Length of head, body and skull are shorter. The sexual skin of pregnant female may swell or redden and adult female that had previously given birth has elongated nipples. |
| Subadult | Body size of subadult is smaller than that of adult. |
| Juvenile | Body size of juvenile is smaller than that of subadult and adult. It also has greater relative tail length, hind foot and ear length. |
| Infant | Infants less than 3 months old have blackish dorsal pelage and bare, pinkish, unpigmented facial skin. Until it is approximately 3 months old, the dorsal pelage turns grayish or brownish in colour. Deciduous canines and first molars will start to grow as it learns to obtain food independently. |

*Data Analysis*

The group size of each macaque group was estimated from the maximum number of visible individuals recorded during any one of the monthly surveys, while the overall population size was estimated from the sum of the maximum group size of each identified group and the solitary individuals. The age-sex composition was estimated based on the number of adult male (AM), adult female (AF), subadult (SA), juvenile (Juv) and infant (Inf).

Monthly macaque encounter rates were computed based on the following formulas:

$$X = \frac{\Sigma\,(n_x + n_y + n_z + \cdots n_i)}{N}$$

Where, $X$ is the mean frequency of encounters at all localities in month $y$ i.e. $\left[\frac{\left(\frac{\text{encounter}}{\text{sample day}}\right)}{\text{surveyed locality}}\right]$, $n_x$ is the mean frequency of encounters at locality $x$ in month $y$ i.e. $\left(\frac{\text{encounter}}{\text{sample day}}\right)$, and $N$ is the number of surveyed localities in month $y$.

$n_x$ was calculated based on the formula:

$$n_x = \frac{\Sigma\,(n_1 + n_2 + n_3 + \cdots n_i)}{N}$$

Where, $n_1$ is the frequency of encounter in sample day *1*, and $N$ is the number of sample days in month $y$.

Macaque encounter rates were also expressed by localities and were calculated based on the following formula:

$$X = \frac{\Sigma\,(n_x + n_y + n_z + \cdots n_i)}{N}$$

Where, $X$ is the mean frequency of encounters during all months at locality $y$ i.e. $\left[\frac{\left(\frac{\text{encounter}}{\text{sample day}}\right)}{\text{surveyed month}}\right]$, $n_x$ is the mean frequency of encounters during month $x$ at locality $y$ i.e. $\left(\frac{\text{encounter}}{\text{sample day}}\right)$, $N$ is the number of surveyed months in locality $y$.

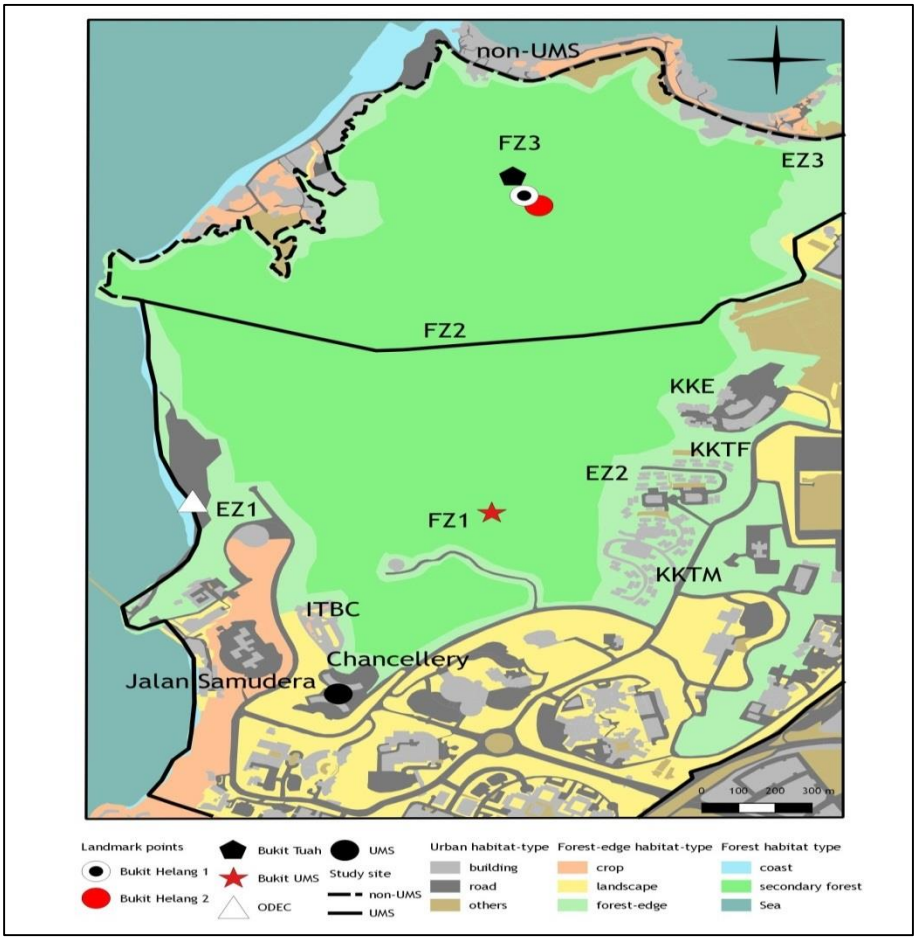


**Figure 2.** Map of our landmark points, study site borders and the localities and features of each habitat type in the main campus of UMS and its vicinity (QGIS, 2018).

To generate the density distribution and heatmap of macaque in UMS campus and its vicinity, we used the Quantum GIS 2.18.24 software (QGIS Development Team, 2018) based on location coordinates data collected from the monthly population surveys, personal sightings and other secondary sightings. We used

the same software to show the overall distribution range of the identified macaque groups and solitary individuals, based on the location coordinates of each identified group and individual collected from the monthly population surveys.

## Results and Discussion

*Number of macaque groups, number of solitary individuals, group size, population size, age-sex composition*

Overall, we sampled 75 days of population surveys over the 12 months survey periods (i.e. 1-12 days of survey per month; monthly average surveys of 6.25 days). The monthly number of detected macaques ranged from 0 to 38 individuals. The monthly population surveys and other personal observations and secondary sightings yielded 103 encounters of a group or individual macaque.

Three macaque groups, namely Group A, Group B, Group C and a solitary individual, were identified. Group A and B were identified based on the number of infants they had, i.e. Group A had two infants, while Group B had four infants. Both groups and the solitary male macaque were sighted at different localities in the campus during a survey conducted in January 2020. Group C was noted as a separate group based on personal observations and the localities where the individual macaques in this group were sighted, which were different from the usual localities where individuals of Group A and Group B were sighted. The group size of Group A was 22 individuals, Group B (21 individuals) and Group C (10 individuals). The estimated population size was 54 individuals. The overall age-sex composition consisted of 8 adult males, 9 adult females, 12 sub-adults, 11 juveniles and 6 infants; 8 individuals were unidentified (Table 2).

**Table 2.** The age-sex composition of the long-tailed macaque population where age-sex is represented by adult male (AM), adult female (AF), sub-adult (SA), juvenile (Juv), infant (Inf) and unidentified (UF).

| Group/Individual | Total individuals | AM | AF | SA | Juv | Inf | UF |
|---|---|---|---|---|---|---|---|
| Group A | 22 | 3 | 5 | 5 | 6 | 2 | 1 |
| Group B | 21 | 3 | 4 | 7 | 2 | 4 | 1 |
| Group C | 10 | 1 | 0 | 0 | 3 | 0 | 6 |
| Solitary | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Total individuals | 54 | 8 | 9 | 12 | 11 | 6 | 8 |

Compared to the group size of long-tailed macaques reported in other university campuses in Malaysia (Universiti Kebangsaan Malaysia: UKM; Universiti Malaya: UM), the group size in our study was much smaller; the mean group size in our study was 17.7 individuals (n = 3), whereas it was ≤ 45.3 individuals (n = 7) in UKM and 49 individuals (n = 4) in UM (Md-Zain et al., 2011; Osman, 1998). On the other hand, the group size range found in our study i.e. 10-22 individuals was rather similar to the ones reported in non-provisioned free-range long-tailed macaque groups that generally consume natural food e.g. 19-25 individuals in Singapore (Sha and Hanya, 2013); ≤ 25 individuals in Kalimantan, Indonesia (Yeager, 1996); and 10-30 individuals in the wild (Fooden, 1995). This would probably be due to food resources and seasonal provisioning. This information is essential for the future assessment of the status of human-macaque interactions in UMS campus because direct (e.g. being fed by humans) and indirect (e.g. anthropogenic food waste-eating) provisioning both can typically affect primate demography. Access to energy-rich artificial food generally leads to an increase in primate birth rate, possibly inducing larger group sizes and greater dependence on anthropogenic food (Rothman and Bryer, 2019), for example, in UKM (Ruslin et al., 2019) and Bukit Melawati, Kuala Selangor (Mohd-Daut et al., 2021) of Peninsular Malaysia. Therefore, even though macaques in UMS may not be highly dependent on anthropogenic food, further evaluation of their dietary choices with detailed food habits is necessary in future studies.

*Macaque density, encounter rate and distribution range*

Based on the estimated population size of 54 individuals in UMS campus and its vicinity, the density of the macaque population estimated over an area of 6.02 $km^2$ was 8.97 individuals/$km^2$**.** Macaques were sighted every month during the study, except in May 2019 due to low sampling effort during that month (Figure 3). Although macaques were encountered in all habitat types as defined in our study i.e. the secondary forest, forest edge and urban areas, the mean frequency of encounters at the 13 surveyed localities varied markedly. Some localities recorded no encounters of macaque, such as at non-UMS area, Forest Zone 1 and Forest Zone 3. Macaques were most frequently encountered at ITBC, followed by KKTF and Edge Zone 2 (Figure 4). In general, the macaques were found to be mostly distributed at two habitat types i.e. the forest edges consisting of Edge Zone 1 near Bukit UMS and Edge Zone 2 near the student residential colleges, as well as the urban areas consisting of the student residential colleges i.e. KKE, KKTF, KKTM, ITBC and Chancellery (Figure 5, Figure 6).

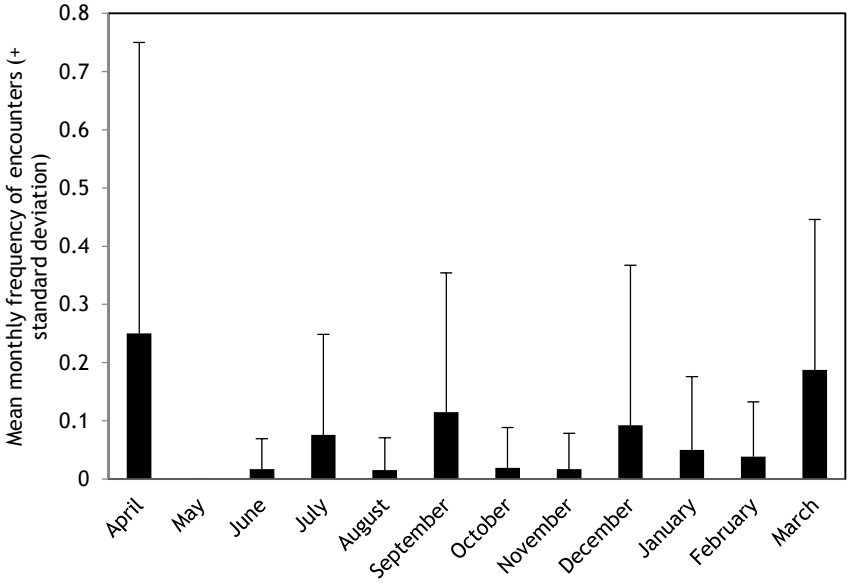


**Figure 3.** Macaque encounter rate i.e. mean monthly frequency of encounters (+ standard deviation) with macaque groups or solitary macaque from April 2019 until March 2020.

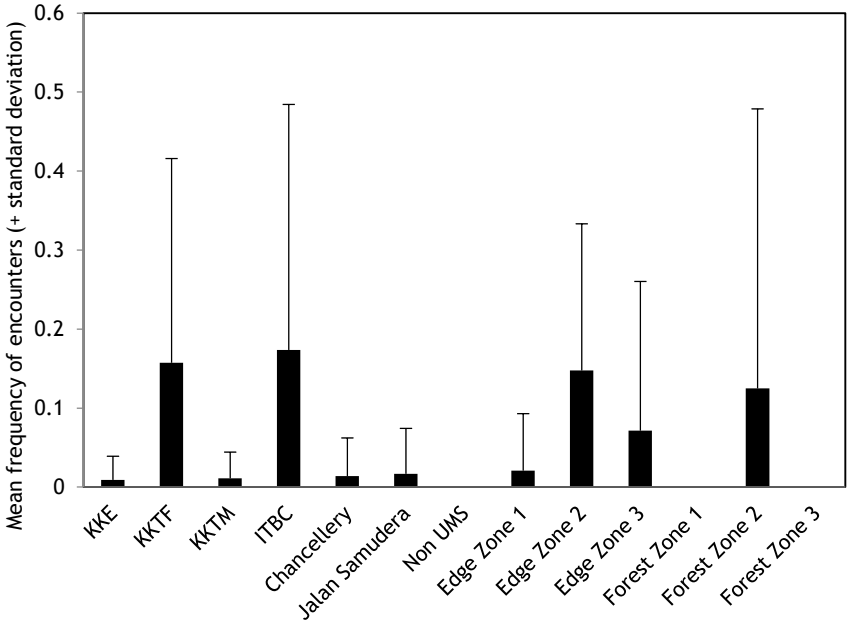


**Figure 4.** Mean frequency of encounters (+ standard deviation) with macaque groups or solitary macaque at the 13 surveyed localities.

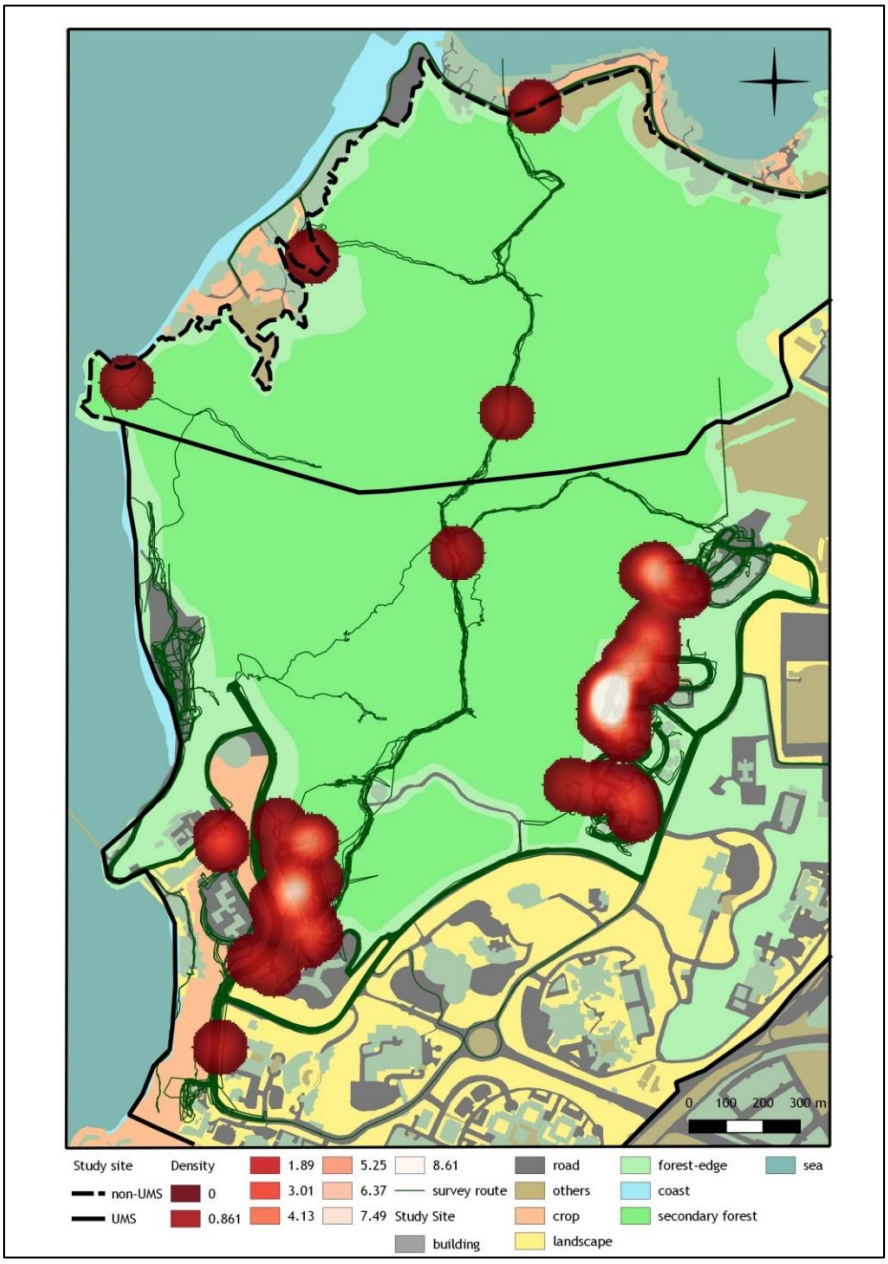


**Figure 5.** Heatmap of macaque distribution in the main campus of UMS and its vicinity from April 2019 to March 2020, with hotspots represented based on the density distribution of the data points i.e. location coordinates collected from the population survey, personal observations and secondary sightings.

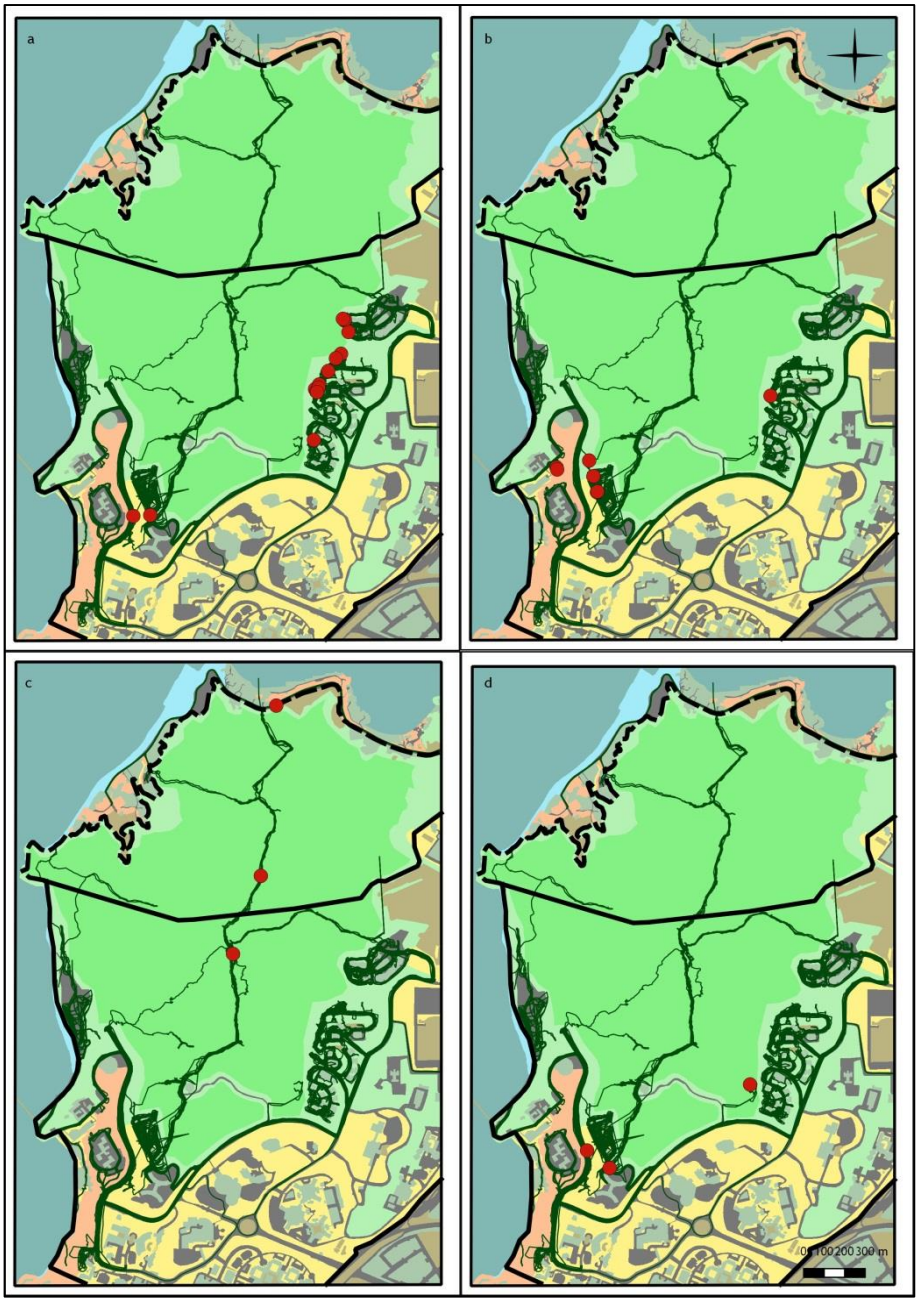


**Figure 6.** Map of macaque distribution range (red dots) in the main campus of UMS and its vicinity from April 2019 to March 2020, with (a), (b), (c) and (d) represented based on location coordinates of Group A, Group B, Group C and solitary individual collected from population survey.

The population density of macaques in our study was lower than that recorded in Singapore i.e. 28.2 individuals/km$^2$ (Sha et al., 2009). As discussed in Sha et al. (2009), even the macaque density in Singapore was much lower than that in other areas like Hong Kong, Bali and Pulau Penutjang off Java, suggesting that the population of long-tailed macaques in UMS campus may not be beyond its carrying capacity. However, since the macaques in UMS were mainly distributed near areas of high human activities (i.e. in the forest edge and urban areas), rather than in the secondary forest, the macaques may simply be more visible in the campus, thus giving a false impression that macaques in the campus area are abundant. Although further studies are needed to elucidate the different types of interactions between humans and macaques on UMS campus, it is essential to monitor the changes in the population density of the macaques. This is to ensure that potential increase in human-macaque interactions resulting from increased macaque population density could be minimised, preventing a more severe human-macaque conflict in the future.

The fact that the encounter rates of macaques varied widely temporally and spatially, as found in this study, suggests that the macaques in UMS prefer to utilise different localities in different months during the study period. The availability of anthropogenic food waste, due to indiscriminate disposal in the campus may potentially affect the distribution patterns of the macaques, especially during certain months in urban areas and forest edge localities near student residential colleges, where the amount of anthropogenic food waste is expected to increase or decrease significantly, depending on the presence or absence of students during the academic semester or off semester periods.

## Conclusion and management implications

The present study has provided some basic information about the distribution and abundance of the long-tailed macaque population that would be instrumental in assessing the status of human-macaque interactions in UMS, so that any negative impacts brought about by such interactions can be ameliorated. In summary, results from the present study showed that long-tailed macaques were found in UMS campus area and its vicinity with an estimated population size of 54 animals and a density of 8.97 individuals/km$^2$. Three groups and a solitary male were present during the study, with group size ranging between 10-22 individuals. Based on our comparison with other studies on macaque populations elsewhere, the population density of long-tailed macaques in UMS campus was generally low and likely to be below its carrying capacity. Furthermore, the macaques were encountered more often in

the forest edge and urban areas where anthropogenic activities are high during certain periods, especially near residential colleges during the academic semesters.

In conclusion, while it is imperative to do more detailed studies, especially on the factors influencing long-tailed macaques monthly distribution patterns in relation to the availability of anthropogenic food waste and natural food in the forest, we suggest the following initial actions should be implemented: firstly, we recommend that the authorities in UMS take appropriate action to make students and staff aware that they should not feed the macaques, directly or indirectly; secondly, educational programmes about the negative impacts of provisioning on the ecology of long-tailed macaques should be endeavoured (e.g. Sha et al., 2009); thirdly, proper management and disposal of anthropogenic food waste including using macaque-proof bins or bin with latches should be implemented at macaque hotspots (Animal Neighbours Project, pers. comms.; Hambali et al., 2019).

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## References

**Abegg C, Thierry B. 2002.** Macaque evolution and dispersal in insular south-east Asia. *Biological Journal of the Linnean Society,* **75(4):**555-576.

**Dickman AJ. 2010.** Complexities of conflict: the importance of considering social Factors for effectively resolving human–wildlife conflict. *Animal Conservation,* **13(5):**458-466.

**Distefano E. 2005.** *Human-Wildlife Conflict worldwide: collection of case studies, Analysis of management strategies and good practices.* Rome: Food and Agricultural Organization of the United Nations (FAO), Sustainable Agriculture and Rural Development Initiative (SARDI).

**Department of Wildlife and National Parks. 2016.** *Annual Report 2016.* Peninsular Malaysia: Jabatan Perlindungan Hidupan Liar dan Taman Negara (PERHILITAN) Semenanjung Malaysia.

**Department of Wildlife and National Parks. 2018.** *Annual Report 2018.* Peninsular Malaysia: Jabatan Perlindungan Hidupan Liar dan Taman Negara (PERHILITAN) Semenanjung Malaysia.

**Eudey AA. 2008.** The crab-eating macaque (*Macaca fascicularis*): widespread and rapidly declining. *Primate Conservation,* **23(1):**129-132.

**Fooden J. 1995.** Systematics review of Southeast Asian longtail macaques, *Macaca fascicularis* (Raffles, 1821). *Fieldiana: Zool., ns,* **81:**2-3.

**Fooden J. 1997.** Tail Length Variation in *Macaca fascicularis* and *M. mulatta*. *Primates,* **38(3):**221–231.

**Fuentes A, Rompis ALT, Arta Putra IGA, Watiniasih NL, Nyoman Suartha I, Soma IG, Nyoman Wandia I, Harya Putra IDK, Stephenson R, Selamet W. 2011.** Macaque behavior at the human–monkey interface: the activity and demography of semi-free-ranging *Macaca fascicularis* at Padangtegal, Bali, Indonesia. In: Gumert MD, Fuentes A, Jones-Engel L. (ed.). *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*. Cambridge: Cambridge University Press.

**Google Earth. 2020.** Universiti Malaysia Sabah.

**Greggor AL, Berger-Tal O, Blumstein DT, Angeloni L, Bessa-Gomes C, Blackwell BF, Clair CCS, Crooks K, de Silva S, Fernandez-Juricic E, Goldenberg SZ, Mesnick SL, Owen M, Price CJ, Saltz D, Schell CJ, Suarez AV, Swaisgood RR, Winchell CS, Sutherland WJ. 2016.** Research priorities from animal behaviour for maximising conservation progress. *Trends in Ecology & Evolution,* **31(12):**953-964.

**Gumert MD. 2011.** The common monkey of Southeast Asia: Long-tailed macaque populations, ethnophoresy, and their occurrence in human environments. In: Gumert MD, Fuentes A, Jones-Engel L. (ed.). *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*. Cambridge: Cambridge University Press.

**Gumert MD, Fuentes A, Jones-Engel L. 2011.** *Monkeys on the edge: Ecology and management of long-tailed macaques and their interface with humans.* (1st ed.). Cambridge: Cambridge University Press.

**Gumert MD, Rachmawan D, Iskandar E, Pamungkas J. 2012.** Population of the

long-tailed macaques (*Macaca fascicularis*) at Tanjung Puting National Park, Central Kalimantan. *Jurnal Primatologi Indonesia,* **9(1):**3–12.

**Hansen MF, Nawangsari VA, van Beest FM, Schmidt NM, Fuentes A, Traeholt C, Stelvig M, Dabelsteen T. 2019.** Estimating densities and spatial distribution of a commensal primate species, the long-tailed macaque (*Macaca fascicularis*). *Conservation Science and Practice,* **1(9):**e88.

**Hambali K, Ismail A, Md-Zain BM. 2012.** Daily activity budget of long-tailed macaques (*Macaca fascicularis*) in Kuala Selangor Nature Park. *International Journal of Basic & Applied Sciences,* **12(4):**47-52.

**Hambali K, Ismail A, Zulkifli SZ, Md-Zain BM, Amir A. 2012.** Human-macaque conflict and pest behaviors of long-tailed macaques (*Macaca fascicularis*) in Kuala Selangor Nature Park. *Tropical Natural History,* **12(2):**189-205.

**Hambali K, Ali N, Hassin NH, Abas MA, Masri MN, Mohamed M, Amir A, Ahamad MKA. 2019.** An innovative design of anti-animal trash bin to solve human-macaque conflict issue. *International Journal of Recent Technology and Engineering,* **8(2 Special Issue 11):**712–714.

**Ilham K, Nurdin J, Tsuji Y. 2017.** Status of urban populations of the long-tailed macaque (*Macaca fascicularis*) in West Sumatra, Indonesia. *Primates,* **58(2):**295-305.

**Jamhuri J, Samantha LD, Tee SL, Kamarudin N, Ashton-Butt A, Zubaid A, Lechner AM, Azhar B. 2018.** Selective logging causes the decline of large-sized mammals including those in unlogged patches surrounded by logged and agricultural areas. *Biological Conservation,* **227:**40-47.

**Karuppannan K, Saaban S, Mustapa AR, Zainal Abidin FA, Azimat NA, Keliang C. 2014.** Population Status of Long-Tailed Macaque (*Macaca fascicularis*) in Peninsular Malaysia. *Journal of Primatology,* **3(1).**

**Kurland JA. 1973.** A natural history of Kra Macaques (*Macaca fascicularis* Raffles, 1821) at the Kutai Reserve, Kalimantan Timur, Indonesia. *Primates,* **14(2-3):**245–262.

**Lappan S, Ruppert N. 2019.** Primate research and conservation in Malaysia. *CAB Reviews,* **14:**1-10.

**Malaivijitnond S, Hamada Y. 2008.** Current Situation and Status of Long-tailed Macaques (*Macaca fascicularis*) in Thailand. *The Natural History Journal of Chulalongkorn University,* **8(2):**185–204.

**Md-Zain BM, Tarmizi MR, Mohd-Zaki M. 2011.** Campus monkeys of Universiti Kebangsaan Malaysia: Nuisance problems and student's perception. In: Gumert MD, Fuentes A, Jones-Engel L. (ed.). *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans*. Cambridge: Cambridge University Press.

**Mittermeier RA, Wilson DE, Rylands AB. 2013.** *Handbook of the mammals of the world: primates*. (1st ed.). Barcelona: Lynx Edicions.

**Osman NAW. 1998.** A study composition and density of long-tailed macaque (*Macaca fascicularis*) in Kuala Lumpur. *The Journal of Wildlife and Parks,* **16**:80-84.

**Mohd-Daut N, Matsuda I, Abidin KZ, Md-Zain BM. 2021.** Population dynamics and

ranging behaviors of provisioned silvered langur (*Trachypithecus cristatus*) in Peninsular Malaysia. *Primates*. doi: 10.1101/2020.12.16.423156

**Otani Y, Bernard H, Wong A, Tangah J, Tuuga A, Hanya G, Matsuda I. 2020.** Factors influencing riverine utilisation patterns in two sympatric macaques. *Sci Rep,* **10:**15749.

**Poirier FE, Smith EO. 1974.** The Crab-Eating Macaques (*Macaca fascicularis*) of Angaur Island, Palau, Micronesia (Part 1 of 2). *Folia Primatologica,* **22(4):**258-282.

**QGIS.org. 2018.** QGIS Geographic Information System. *QGIS Association*. http://www.qgis.org

**Redpath SM, Young J, Evely A, Adams WM, Sutherland WJ, Whitehouse A, Amar A, Lambert RA, Linnell JDC, Watt A, Gutierrez RJ. 2013.** Understanding and managing conservation conflicts. *Trends in Ecology & Evolution,* **28(2):**100-109.

**Riley CM, Jayasri SL, Gumert MD. 2015.** Results of a nationwide census of the long-tailed macaque (*Macaca fascicularis*) population of Singapore. *Raffles Bulletin of Zoology,* **(63):**503–515.

**Roos C, Boonratana R, Supriatna J, Fellowes JR, Groves CP, Nash SD, Rylands AB, Mittermeier RA. 2014.** An updated taxonomy and conservation status review of Asian primates. *Asian Primates Journal,* **4(1):**2-38.

**Rothman JM, Bryer MAH. 2019.** The effects of humans on the primate nutritional landscape. In: Behie A, Teichroeb JA, Malone N. (eds.). *Primate Research and Conservation in the Anthropocene*. Cambridge: Cambridge University Press.

**Ruslin F, Matsuda I, Md-Zain BM. 2019.** The feeding ecology and dietary overlap in two sympatric primate species, the long-tailed macaque (*Macaca fascicularis*) and dusky langur (*Trachypithecus obscurus obscurus*), in Malaysia. *Primates,* **60:**41-50.

**Saaban S, Yazid AZ, Mustapa AR, Keliang C. 2016.** Human-Wildlife Conflict in Peninsular Malaysia – Current Status and Overview. *Biodiversity Forum 2016: Human-Wildlife Conflict Mitigation and Action in Agricultural Sector*. Available from: URL: http://www.mpoc.org.my/upload/13144901_HUMAN_WILDLIFE_CONFLICT_IN_PENINSULAR_MALAYSIA_CURREN_STATUS_AND_ OVERVIEW.pdf (Awana Resort, Genting Highlands, Malaysia).

**Sha JCM, Gumert MD, Lee BPH, Fuentes A, Rajathurai S, Chan S, Jones-Engel L. 2009.** Status of the long-tailed macaque *Macaca fascicularis* in Singapore and implications for management. *Biodiversity and Conservation,* **18(11):**2909-2926.

**Sha JC, Hanya G. 2013.** Diet, activity, habitat use, and ranging of two neighboring groups of food-enhanced long-tailed macaques (*Macaca fascicularis*). *American Journal of Primatology,* **75(6):**581-592.

**Soulsbury CD, White PC. 2016.** Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. *Wildlife Research,* **42(7):**541-553.

**Southwick CH, Cadigan FC. 1972.** Population studies of Malaysian

primates. *Primates,* **13(1):**1-18.

**Sussman RW, Tattersall I. 1986.** Distribution, abundance, and putative ecological strategy of *Macaca fascicularis* on the island of Mauritius, Southwestern Indian Ocean. *Folia Primatologica,* **46:**28–43.

**Swan GJ, Redpath SM, Bearhop S, McDonald RA. 2017.** Ecology of problem individuals and the efficacy of selective wildlife management. *Trends in Ecology & Evolution,* **32(7):**518-530.

**Tee SL, Solihhin A, Juffiry SA, Putra TR, Lechner AM, Azhar B. 2019.** The effect of oil palm agricultural expansion on group size of long-tailed macaques (*Macaca fascicularis*) in Peninsular Malaysia. *Mammalian Biology,* **94(1):**48-53.

**Umapathy G, Singh M, Mohnot SM. 2003.** Status and Distribution of *Macaca fascicularis umbrosa* in the Nicobar Islands, India. *International Journal of Primatology,* **24(2):**281–293.

**Yeager CP. 1996.** Feeding ecology of the long-tailed macaque (*Macaca fascicularis*) in Kalimantan Tengah, Indonesia. *International Journal of Primatology,* **17(1):**51-62.