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Human-macaque conflicts at a human settlement in Riau Province, Indonesia

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Abstract. *Metananda AA, Sutopo, Gunawan, Nurjaman, Dani R, Ruhyat Y, Sutopo, Ahmad, Aprianto A, Naibaho J, Afrianto WF. 2024. Human-macaque conflicts at a human settlement in Riau Province, Indonesia. Biodiversitas 25: 2950-2958.* Various human activities have caused the loss and degradation of the natural habitat of macaques, resulting in their share habitat with high levels of human activities. The proximity of macaque habitats to human activities may increase potential human-macaque conflicts. This research aims to observe the conflict between humans and macaques, especially *Macaca fascicularis* (Raffles 1821), by identifying macaque population parameters, including the number of groups, group distribution, home range, sex ratios, and age structure in the Pertamina Official Housing (POH) complex, Dumai District, Riau Province, Indonesia. Population data were acquired through a census inventory using concentration count and exploration methods. The results showed the population of 461 macaque individuals belonging to 19 groups which were spread over 17 points in the study area. Based on the sex ratio, juveniles were the most predominant group with 104 individuals. The distribution of individuals indicated that there were several groups with varying numbers and structures at one observation point. Factors that caused macaque disturbance include food availability, habitat space availability, community habits and behavior, and safety. Macaque disturbance included attacks on children, damage to lighting, roofs, fruit trees, vegetable plants, and the presence of *M. fascicularis* groups in large numbers in the area traversed by residents. We recommend improving the management of *M. fascicularis* habitat, conducting population control, and educating the community about behaviors that can trigger disturbances. In addition, mitigation measures and regular monitoring must be carried out to find effective long-term solutions.

Keywords: Distribution, disturbance, *Macaca fascicularis*, population, sex ratio

INTRODUCTION

There is an increasing trend on the loss and degradation of macaques habitat which is largely driven by human population growth, settlements development and agricultural expansion (Tilman et al. 2017). As the consequence, human-macaque interactions are increasing due to the limited remaining habitat for macaques, resulting in the conflicts between human versus macaques (Chowdhury et al. 2020). Macaques might disturb human settlements to find food to survive and they continue to return and live around residential areas since food is easier to find (Mendis and Dangolla 2016; Ganguly et al. 2018). According to Kamarul et al. (2014), groups of macaques will appear in areas close to human settlements because of the high availability and distribution of food. Macaques also demonstrate a tendency to favour food from humans, such as leftovers and food given directly by humans (Gumert et al. 2011).

Human-macaque interaction can influence the ecology and behavior of macaques (Abdul-Nasir et al. 2021). Due to their disruptive nature and opportunism, several macaque species are also categorized as pests or nuisance animals (Hambali et al. 2012; Kamarul et al. 2014). Some types of macaques demonstrate aggressive behaviors, as well as a tendency to seize objects belonging to humans, steal food, rummage trash cans, enter residential areas and buildings, and even damage physical properties (Md-Zain et al. 2014). For example, many studies have reported *Macaca fascicularis* (Raffles 1821) disturbances in various places, such as campuses, tourist destinations, farms, settlements, and sacred places (Hambali et al. 2014; Mishra et al. 2020; Syah 2020; Abdul-Nasir et al. 2021; Indriani et al. 2021; Marpaung et al. 2023). Conflicts between humans and macaques may trigger extreme measures, such as macaque hunting in an effort to reduce their population (Das and Mandal 2015). In addition, macaques can also be a medium for transmission of zoonotic diseases to humans through contamination of food, water and interactions (Stark et al. 2019; Kurniawati et al. 2020; Nada-Raja et al. 2022; Narapakdeesakul et al. 2023).

Macaca fascicularis Raffles (Primates: Cercopithecidae) is commonly known as the crab-eating macaque or the long-tailed macaque (Hambali et al. 2012). *Macaca fascicularis* is distributed in 20 Asian countries and is considered native to Southeast Asia (Fooden 2006; Gumert 2011). It is easy to find, especially on islands with a

tropical climate (Eudey 1987). In Indonesia, *M. fascicularis* is widespread almost throughout the region (Lekagul and McNeely 1977). Despite its wide distribution and abundance, the species has a conservation status of endangered under the IUCN Red List since 2022, changing from being least concern in 2008 to vulnerable in 2021 (Hansen et al. 2022). In Indonesia, the species is not protected by Indonesian law (Maharadatunkamsi et al. 2023).

This study investigates macaque disturbances reported in the Pertamina Official House (POH) complex of PT Kilang Pertamina International Refinery Unit II Dumai, Riau Province, Indonesia. This study aims to identify the parameters of macaque population, including the number of groups, group distribution, home range, sex ratios, age structure, and carrying capacity, which can serve as a reference in determining the ideal population that must be maintained at the study site. The above demographic data and field observations are essential information to formulate a strategy for dealing with macaque disturbance. This study offers a win-win solution that considers macaque conservation as well as the safety and comfort of the people living in the official housing complex. The solutions provided by this study are expected to minimize disturbances often experienced by the surrounding community, while also considering macaque carrying capacity and sustainability. In a broader context, this study might provide an example of how population ecology can be used to understand human-macaque conflict and develop conservation measures which can be replicated in other contexts of areas and situations.

MATERIALS AND METHODS

Study area

The study was carried out in the POH complex of PT Kilang Pertamina Internasional Refinery Unit II Dumai on March 21-24, 2023 (Figure 1). The POH facilities are provided as part of employee welfare, especially for those assigned to operational areas. The facilities at the POH, such as electricity, water, and other supporting services that facilitate the daily lives of the employees. Within the Pertamina RU II Dumai complex, there is an urban forest named Eco Park Patra Seroja. Several flora in the forest area include *mahang*, *renghas*, wild ferns, lianas, rattan, and pitcher plants. Meanwhile, the existing fauna found in the area consists of marsh turtles, green magpie birds, forest bulbul birds, *lutung* monkeys, *drongo* birds, and *punai* pigeons.

Data collection procedures

Macaque population data were obtained through a census inventory using concentration count and exploration methods. According to Kuswanda and Barus (2017), the concentration count method effectively determines wild animal populations with a group lifestyle. Several steps of the concentration count method adopted for the study were explained as follows. First, data were obtained through interviews and field observations. The resulting data were used to determine the places and times when macaques typically gather. Subsequently, the macaque population was observed to collect parameters at each encounter, including group determination, the number of individuals, sex, and age class (Table 1).

Data of macaque groups were determined using the exploratory method, namely by walking along the housing complex road. Due to the changing locations of macaque gatherings, the observation teams were divided to minimize the potential of double counting. The position of macaques was recorded using the Avenza Maps. In addition, gathering time, the number of individuals, the sex ratio, the age structure of each individual were also recorded.

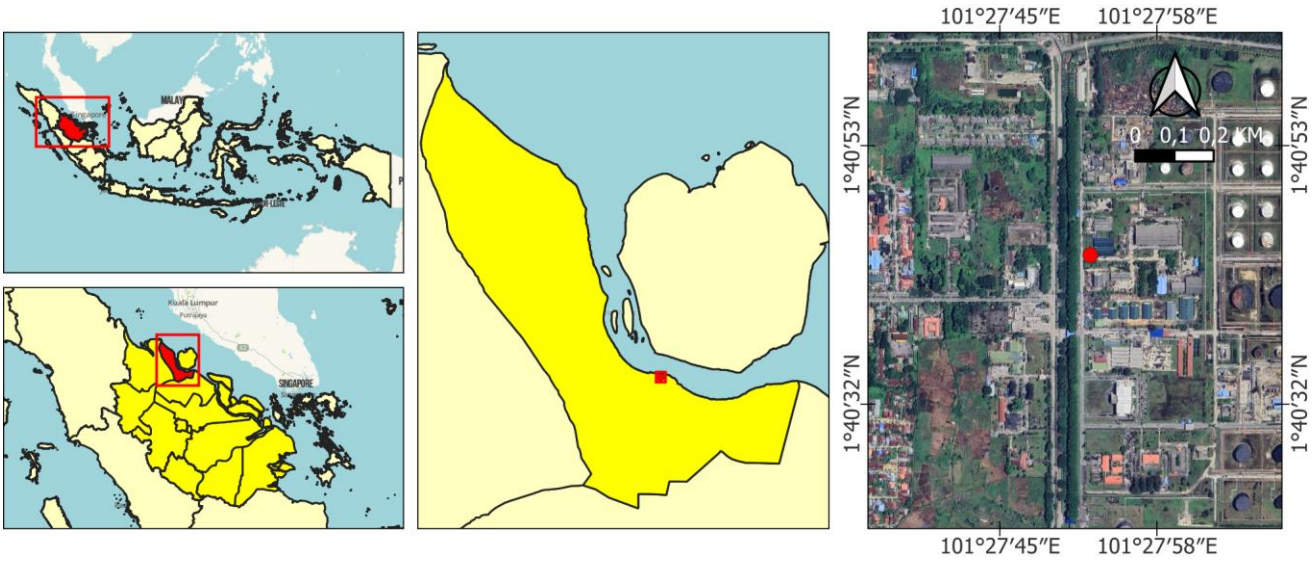

Figure 1. Map of study location in Pertamina Official House (POH) complex, Dumai District, Riau Province, Indonesia

Table 1. Classification of macaques age class

Age class	Characteristic
Infant	Dependent on their mother, small body size, black fur color and clinging to their mother's arms.
Juvenile	Able to stand alone at feeding time, but tend to sleep near their mother. Remain playful, with body size smaller than subadults and reproductively immature—generally not stray far from their mother.
Subadult	Able to stand alone or in a group. Their body size is almost similar to that of adult macaques, but they can be distinguished from their behavior as they are still in the learning stage in mating activities. • Male: Tend to congregate with other adolescents, have a scrotum, and lighter grey color than adults, which tend to be darker • Female: Not carrying infants, not attached to their mother, and have faint nipples.
Adult	• Male: Adults have a mustache, largest body size, visible scrotum, stocky appearance, fused sitting pads and look more stable. • Female: Adults have bushy sideburns and beards, smaller bodies than adult males, clear nipples, and separate sitting pads between the right and left.

The macaque population distribution was determined by observing the species and validated based on the exploration results by circling the entire area of the POH. The habitat area size was calculated after selecting the population's location, followed by the determination of home range. The community confirmed the determination of the home range and the distribution of macaques through interviews. Coordinates were determined using the Avenza Maps, including points where the actual population was identified, the habitat's outermost boundary, and the home range's outermost boundary. The outer boundary points of the home range were determined, the habitat area was defined, and the home range external boundary points that provide the home range location were selected. The size of the habitat was determined by connecting the outer coordinate points of the habitat. These points were connected by an imaginary line using the Avenza Maps application.

Factors causing macaque disturbance were obtained from direct observation and interviews with employees and several security officers in the complex. Factors driving the disturbances were divided into two factors, namely internal factors and external factors. The external factors referred to factors originating from outside the POH area and were not examined in this study. The internal factors investigated in this study included the availability of food in the study sites (natural food and leftover food), the availability of habitat space, the habits and behavior of humans toward macaques, and the different safety factors.

All forms of disturbances were recorded, including activities that cause damage to plants, especially fruit trees, food theft, trash-can scavenging resulting in scattered trash on the street, disturbance to pets, or physical disturbances experienced by residents. The disturbances caused non-material impacts such as trauma, damage to public facilities, and the security and comfort of residents.

Data analysis

The data analysis was divided into several aspects, including macaque population demographic parameters, distribution characteristics, causes of disturbance, and forms and impacts of disruption caused by overlapping locations of macaques and the community. This study utilized qualitative descriptive analysis, which included collecting, processing, analyzing, and presenting data descriptively. Qualitative descriptive data analysis is often used to analyze events, phenomena, or social situations. For the parameter data of macaque population, a quantitative study was carried out with the following calculations.

Estimation of population size and population density was obtained by counting the number of individuals per study area using the following formula:

$$D = P/A$$

Where: D = density; P = population; A = area.

Sex ratio was obtained by counting the number of males and females (Hartati et al. 2023) using the following formula:

$$S = Y/X$$

Where: S = sex ratio; Y = number of male individuals; X = number of female individuals.

RESULTS AND DISCUSSION

Populations of *Macaca fascicularis*

Based on the result of a survey using the concentration count method at each point where macaques were distributed, the macaque population consisted of 461 individuals in 19 groups spread over 17 points in the POH area. Based on the identification on the age structure, the macaque population was divided into four age classes: adults, subadults, juveniles, and infants. The juvenile group had the most individuals within the POH area (104 individuals) followed by 94 subadult males, 97 adult females, and 91 subadult females (Table 2). The number of *M. fascicularis* individuals was much higher than the urban ecosystem type in West Sumatra, Indonesia with 172 individuals (Ilham et al. 2017). However, Boonkusol et al. (2018) stated that the population of *M. fascicularis* in Old Town, Lopburi Province, Thailand, was higher at 70-700 individuals. Documentation and monitoring of macaque population is essential in ensuring the carrying capacity of its habitat (Perwitasari-Farajallah et al. 2023). The large populations of *M. fascicularis* have been reported to be a severe problem in urban-dominated countries such as

Singapore (Riley et al. 2015).

Adults and subadults were easily recognized by the characteristics of their genitals and nipples, while juveniles and infants were easier to recognize by their behavior and body size. Juveniles tended to play more with individuals at their age, while infants spent more time in their mother's arms. From physical signs, juveniles generally had black hair. In addition to carrying their infants, the mothers monitor their infants' movements to ensure safety (Hambali et al. 2012). Although rare, the mothers can be as aggressive as the pig-tailed alpha males if food resources are limited (Dzulhelmi et al. 2019). Individual infants cannot walk steadily, and therefore whenever group members moved, the mothers carried their infants on the chest, or the infants hang on the mothers' chest and stomach. Dominant adult males had larger body sizes than other adult males and were more distant from their group members (Figure 2). The characteristics of males with a larger body size and aggression make them dominant in the social hierarchy (Kamarul et al. 2014). Macaques tended to live in groups consisting of several male and female individuals. They adhere to a promiscuous mating system where male and female macaques generally mate with many partners, which is known as a multimale multifemale group (Al-Hakim et al. 2023). The hierarchical system in the social life of *M. fascicularis* is vital as alpha and beta males and female macaques usually appear (Kamarul et al. 2014). Being in a group makes it easier to warn each other of predators or disturbances (Hambali et al. 2012).

Distribution of *Macaca fascicularis*

The observations showed that there was more than one group with a different number of individuals and structures, including *M. fascicularis* population around Dahlia Street, which consisted of three groups, namely Group 2, 3, and 4. Using a polygon on the outermost boundary of the identified habitat, the distribution range of *M. fascicularis* was 571.31 ha or 5.71 km^2 (Figure 3.A). The observation also showed that *M. fascicularis* population density of 0.81 individuals/ha, indicating a high-density area and that people tend to incidentally find *M. fascicularis* more easily at various situations. The *M. fascicularis* group in the POH was spread over 17 points, and each had a habitat that must be maintained with other groups (Figure 3.B). Meanwhile, in this study, we also found the *Macaca nemestrina* (Linnaeus 1766) group, which was only found at one point, tended to inhabit a wider area, and the presence of other primates was not a limiting factor for the macaques in controlling their range. The points where *M. fascicularia* and *M. nemestrina* meet tended to have a fixed pattern, meaning they already had territory that must be defended from other *M. fascicularis* groups. According to Dzulhelmi et al. (2019), the two macaque species have never been reported to fight over food. These species are also reported to have different habitat preferences (Rodman 1991; Yanuar et al. 2009). Thus, the presence of one group with another group is a limiting factor in movement.

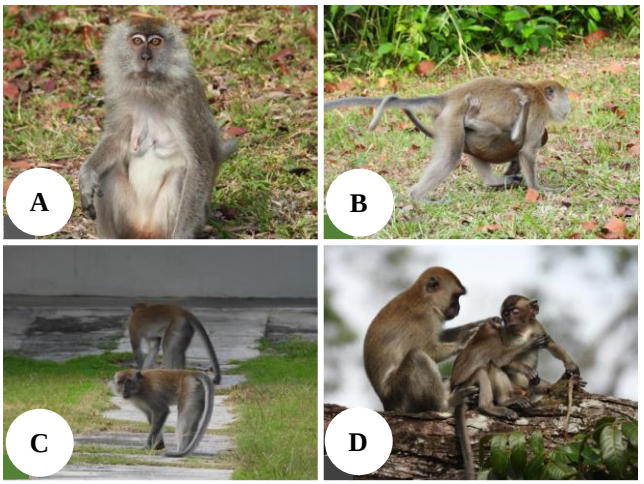

Figure 2. Individual of *M. fascicularis* in Pertamina Official House (POH) complex, Dumai District, Riau Province, Indonesia: A) adult female; B) adult female carrying an infant; C) dominant adult male; D) adult female grooming an infant

Table 2. Population and age structure of *Macaca fascicularis* in study area

Group name	Adult male	Adult female	Subadult male	Subadult female	Juvenile	Infant
Group 1	4	4	9	7	14	0
Group 2	3	5	4	4	4	2
Group 3	8	13	9	8	9	3
Group 4	4	9	5	6	5	0
Group 5	5	7	5	11	17	2
Group 6	4	5	4	5	7	3
Group 7	3	2	3	4	3	0
Group 8	5	3	3	3	0	0
Group 9	2	4	3	5	2	0
Group 10	4	6	4	7	5	3
Group 11	3	4	3	6	8	2
Group 12	5	6	6	5	12	2
Group 13	1	0	0	0	0	0
Group 14	4	5	1	2	4	0
Group 15	5	6	4	5	4	0
Group 16	3	4	4	3	3	0
Group 17	1	2	1	3	0	0
Group 18	11	5	4	4	7	0
Group 19	3	7	2	3	0	0

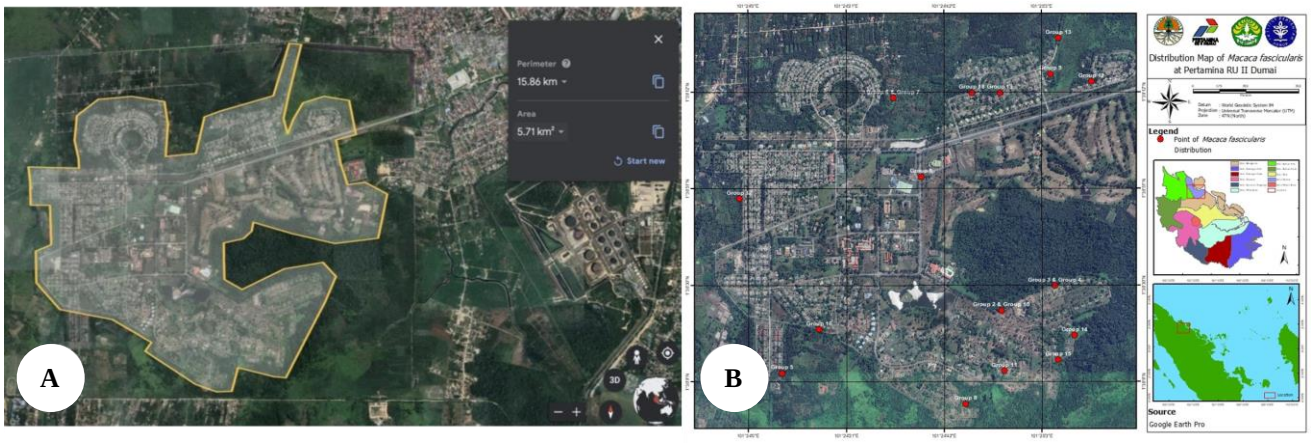

Figure 3. A) Delineation and B) distribution of *M. fascicularis* population in Pertamina Official House (POH) complex, Dumai District, Riau Province, Indonesia

Overcrowding sometimes resulted in excessive agonistic behavior and even seemed to lead to infanticide attempts by other males against individuals that were not close relatives. The observations on the Group 2, 3 and 4 on Dahlia Street showed that there were adult males with permanently disabled right legs, and these males were utterly alienated from other group members. Another primate group was found in the studied area, namely the silvered langur (*Trachypithecus cristatus*), with a total of 24 individuals spread over three points, namely 15 individuals located in Wijaya Kusuma Street area, which occupied a habitat starting from Sasana Mitra Bukit Datuk, Telaga to the area around Patra Seroja Eco Park. In addition, one individual was found in Bunga Street, and eight were found in Cendrawasih Street. According to Wan-Azman et al. (2021), in areas with many humans, *T. cristatus* tends to quickly leap when encountering humans or make alarming sounds when they feel threatened. However, langurs can also be habituated to visitors. The presence of *T. cristatus* in the POH area tended not to cause disturbance as these primates tend to be shy and picky in their search for food, which consists of leaves and fruit. In contrast to *M. fascicularis*, they generally ate any food other than leaves and carrion.

Identification food type

Based on the observations, the food consumed by *M. fascicularis* can be categorized into two types: natural and artificial foods. According to Sha and Hanya (2013), food enhancement decreases day ranges and home range size and drives animals to spend less time in transiting and feeding and more time resting. The types of natural food observed for *M. fascicularis* included bananas, papaya, guava, guava, mango, rambutan, coconut, *matoa*, wild tamarind, jackfruit, ficus seeds, cape fruit, and Indian almond seeds. According to Kassim et al. (2017), fruit trees commonly consumed by *M. fascicularis* have the highest nutritional content, such as *Areca catechu*, *Terminalia catappa*, *Elaeis guineensis*, and *Cascabela thevetia*. The types of fruit trees for macaques indicate that they are frugivorous (Hambali et al. 2014). However, *M. fascicularis* may become opportunistic omnivores in the event of low fruit availability (Ritonga et al. 2022). This type of natural food may still increase because this study needed to identify all the natural food in the POH area in detail, especially in forested areas, such as the Patra Seroja Ecopark. *Macaca fascicularis* also ate coconut leftovers that had been peeled by humans or hollowed out by squirrels. In tourist locations or areas that are densely populated with humans, *M. fascicularis* prefers artificial food (Yamin et al. 2022). The shift in dietary behavior occurs due to habituation to humans (Nila et al. 2014).

Identification of habitat space availability

In the landscape context, extensive space was available for *M. fascicularis* or other primate habitats within the POH complex. The rough delineation results based on the sketch of the official housing complex indicated an area of 1,518 ha, with the *M. fascicularis* having a distribution range of 571.31 ha (Figure 4). From this area, the complex had a concentration of *M. fascicularis* or an abnormal distribution. They spread out and concentrated only in areas directly adjacent to housing or ecotones between housing and the non-residential areas, such as dense forests, shrubs, and oil palms.

The abnormal distribution indicated a factor that attracted the attention of *M. fascicularis* group to the area directly adjacent to the POH area. In addition, observations during the survey showed that *M. fascicularis* tended to distribute in poor habitat quality, especially in terms of food sources, shelter, and security to the groups. Changes in the habitat quality are predicted to last a long time. It was not only the decrease in the habitat quality in the POH area but also the fact that the outside areas were increasingly experiencing a decrease in habitat quality by changing land cover to other functions such as settlements and plantations.

Figure 4. Potential suitable habitat map for macaques in Pertamina Official House (POH) complex, Dumai District, Riau Province, Indonesia

Thus, the group preferred areas with slightly better habitat quality than those that had to experience extraordinary pressure, especially outside the POH area. The availability of anthropogenic food is positively correlated with macaque consumption (Zhao et al. 2023). When human traffic is high, fewer affiliative interactions between macaques and humans result in less social behavior within the group (Entezami et al. 2024). Therefore, human foods are essential in changing the critical behavioral ecology of ape groups (Hasan et al. 2023).

Identification of habits and behavior

The observations showed several harmful habits or behaviors of *M. fascicularis,* such as throwing trash filled with food scraps into the open area that potentially invited animals to approach and pick up the leftovers. Another habit was residents' compassion for animals, especially *M. fascicularis*, which indirectly changed *M. fascicularis* habits to prefer leftovers rather than natural food. Human food has more spices than natural foods. Feeding food to *M. fascicularis* changed their natural behaviors to being fearless to humans, even in the presence of car/motorcycle drivers since they thought the drivers would provide them with food. This habit eventually formed a learning behavior to wait for approaching motorists, or attack residents who bring food. According to Marty et al. (2019), the assertiveness of humans and relations with macaques will impact their social behavior.

The POH complex was relatively safe, especially from disturbances by the surrounding community as outsiders were not permitted to enter the complex without permission from the housing management. Compared to areas outside the POH, the *M. fascicularis* group preferred the POH complex. Besides food and habitat quality, *M. fascicularis* appeared to be more insecure in other areas because the residents often chased them away. The relationship between human and macaques can also increase potential stress for macaques (Maréchal et al. 2016; Marty et al. 2019). In addition, there were no leftovers in the outside areas compared to the POH complex. The outside areas were also planted with fruits and vegetables, but there did not appear to be any disturbance from *M. fascicularis.* The management of POH complex had made efforts to reduce the impact (mitigation) of macaque disturbance, such as installing warning signs. However, this method was not very effective in reducing disturbances, as evidenced by the large number of groups of *M. fascicularis* that rummaged through trash cans to look for leftovers.

Form and impact of macaque disturbances

Based on observations, the common disturbance caused by macaques was messy and scattered waste. A similar incident is also reported in the Universiti Malaysia Sabah campus area (Zhao et al. 2023). According to the pest control officers of the POH complex, macaque disturbance in the study included attacks on children who were playing which caused injuries and damage to lighting, roofs, fruit trees and vegetable plants in the area. Another visible

disturbance at the time of observation was the presence of *M. fascicularis* group in large numbers congregating in the road traversed by residents, causing safety concerns to motorists, especially bicycle and motorcycle riders (Figure 5). This condition requires resolution of human-macaque conflicts in an integrative and holistic manner, especially regarding how each party responds to and changes the other party's behavior (Beisner et al. 2014; Suwondo et al. 2023).

Measures to control macaque population

Reducing macaque population in the POH complex using capture management potentially reduced some (50%) or most of the population of existing *M. fascicularis* (with a remaining maximum population of 10 individuals). This reduction also considered aspects of the demographic parameters of the population. This reduction was based on ecological considerations, which included the *M. fascicularis* group returning to the POH complex. Efforts to reduce the population can impede the population growth rate, and new disturbances may reoccur after relocation for the next few years. This population reduction can be carried out by relocating *M. fascicularis* population to another location with good forested habitat criteria, not adjacent to settlement areas, and ensuring that the *M. fascicularis* population at the release location does not have a high density to ensure further carrying capacity to meet the needs of the *M. fascicularis* group originating from the study site.

Population reduction should be prioritized at the points/areas of distribution of *M. fascicularis* group, which had a higher and more massive level of disturbance. The Riau Natural Resources Conservation Agency (BBKSDA Riau) and POH complex management must prepare adequate temporary shelters to place the captured *M. fascicularis* before being transferred to release locations. BBKSDA Riau and POH complex management can use traps of a specific shape and size. If the approach is ineffective, they can use the services of the *Baduy* people who are used to capturing *M. fascicularis*. The capture of the *M. fascicularis* group must be carried out thoroughly. Individuals are not allowed to leave their groups, especially infants as they still need care from their parents and are at risk of being abandoned and unable to survive on their own. Leaving a small number of juveniles or adult males of *M. fascicularis* (one individual) is also not allowed since it will make it difficult for the remaining individuals to be accepted by other *M. fascicularis* groups who have yet to be captured. The juveniles cannot be abandoned as well because, at their age, they still need the parents and other group members to grow and develop their behavior.

The implementation of macaque disturbance mitigation can utilize direct education (corrections, explanations, warnings, or sanctions) to employees living in the POH complex regarding behaviors that can harm *M. fascicularis*. This would improve the quality of *M. fascicularis* habitat outside the POH complex area, which is hoped to attract population concentrations outside the complex area and restore their natural behavior of preferring natural food. The quality of waste disposal areas should improve by not using open trash cans or replacing them with closed containers that are difficult for *M. fascicularis* to open, thereby potentially reducing the number of waste disposal areas. For example, two to three houses may share one large waste disposal area. Waste disposal areas should be segregated, with food waste not combined with plastic waste. It applies high discipline to the pattern of household waste disposal and its collection by waste collection staff. For example, it is prohibited to dispose of garbage from 5.30 a.m. to 6.00 p.m., and residents are only allowed to dispose of waste between 7.00 p.m. and 5.00 a.m., after which the cleaning staff will pick up the trash from 6.00 a.m. to 7.00 a.m. This consideration is based on the daily behavior pattern of macaques, which tend to be active at certain hours and passive/rest at night. Various forms of disturbance caused by *M. fascicularis* should be monitored, including disturbance time, form, location, and impact to obtain time series data regarding the volume and intensity of disturbance in the POH complex. Monitoring can be accumulated in weeks, months or years.

Figure 5. The disturbance of macaque troop in the road of Pertamina Official House (POH) complex, Dumai District, Riau Province, Indonesia

In conclusion, the study found a population of *M. fascicularis* consisting of 461 individuals from 19 groups spread across 17 points in the POH area. The existing population structure is quite balanced in sex ratio composition and age structure. The distribution of *M. fascicularis* was 571.31 ha or 5.71 km^2 and had a density value of 0.81 individuals/ha. This value indicated a high density for that size area, so people tended to find *M. fascicularis* more easily and often at various points of the complex. The sex ratio and age structure of *M. fascicularis* found were adult male (78 individuals), adult female (97 individuals), subadult male (74 individuals), subadult female (91 individuals), juvenile (104 individuals), and infant (17 individuals).

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