Initial Investigation of Sulawesi Moor Macaque (*Macaca maura*) in Tabo-tabo Forest, South Sulawesi - Indonesia

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Abstract. Sulawesi black crested macaque (*Macaca maura*) is one of the seven endemic macaques inhabited Sulawesi Island and is mainly found in the Southern part of Sulawesi. This species is classified as an endangered species by the International Union for Conservation and Nature (IUCN). The aim of this research was 1) to examine the home range of *M. maura* and daily activity of the species, 2) to determine tree species used by the species as diet sources and resting trees in Tabo-tabo Forest, Pangkep Regency (South Sulawesi – Indonesia). The home range was measured by connecting coordinate points passed by a moor macaque group in the area for 6 consecutive days. Meanwhile, daily activity of the species was monitored by using scan sampling method for sampled individuals in three observation periods. Direct observation was carried out to identify diet and resting tree species. It was found that the moor macaque group had 22.06 ha width of home range with the total distance around 6.64 km. The daily distance spent by the group was between 0.9-1.5 km or in average was 1.1 km. The highest activities known to be feeding (30.4%) and then followed by moving (25.3%). While resting activities was allocated for 24.7%. The least activities recorded were social activities (19.6%).

Tree species used by the group as diet and resting trees were *Anthocephalus chinensis* and *Dracontomelon dao*. The tree species known to be a diet tree only were *Garcinia nervosa*, *Arenga pinnata*, *Flacourtia rukam*, *Ficus* sp., *Eugenia cuminii*, *Gastonia serratifolia*, *Mangifera* sp., *Spondias dulcis*, and *Muntingia calabura*.

1. Introduction

Sulawesi is biogeographically the most unique island among any other islands in Indonesia where it is laid within the biogeographical area of Wallacea Line. The area has the highest level of fauna endemicity in particular mammals [1]. Sulawesi black macaque (*Macaca maura*) is one of 7 endemic species of macaques in Sulawesi. The macaque is generally scattered in South Sulawesi while other six species are spread on other parts of Sulawesi [2–5]. Further, Riley [6] had described the locations of macaques on the island of Sulawesi geographically, *M. tonkeana* can be found in Central Sulawesi and *M. hecki* is inhabited North Central Sulawesi. Meanwhile, *M. nigrescens* is situated near Gorontalo-Kotamobagu and *M. nigra* is known to be distributed in North Sulawesi. *M. ochreata* is located in Southeast Sulawesi and *M. brunnescens* can be seen on the islands of Muna and Buton.
M. maura is the only species of macaques naturally existed in South Sulawesi living in various habitats including grasslands, lowland forests, to tropical mountainous areas, from limestone and ultrabasic areas to even secondary forests or nearby human settlement. The species is also known to spread across regencies of South Sulawesi. M. maura is classified as an endangered species by the IUCN (The International Union for Conservation of Nature) [1] and by the Government of Indonesia it is protected under the law Indonesian Government No. 106/2018 regarding preservation of plant and animal Species. In the international convention on Trade in Wild Plant and Animal Species (Convention on International Trade of Endangered Flora and Fauna Species), the Sulawesi black macaque is included in Appendix II.

As many other frugivorous primates, M. maura has played significant contributions for the environment not only as seed disperser which is very important for sustaining forest regeneration and restoring vegetation in degraded forests but also assisting high density of seedlings and saplings and supporting the process of gene flow among plant’s populations [7]. However, M. maura as one of the endemic animals is currently threatened with extinction. Anthropogenic factors such as habitat fragmentation and changes have become the major threats for the survival of the species where more than 50% of the populations are declining over three decades [3]. Existing populations are now inhabited heavily fragmented habitats in particular in South Sulawesi karst areas [3,8] and only half of the areas are classified as protected areas [9] with scattered and isolated conditions of remaining forests in the southwestern part [8]. Ali kodra [10] stated that the reduction in forest areas and the decline in forest quality as habitat emerged problems for wildlife and their conservation efforts. Increasing human population has also play significant impacts on both populations and habitats [11] in particular for M. maura.

Home ranges are often defined as areas where animals reside or area utilized for food foraging or finding mates in periodical basis [12]. The range of each animal is generally different, depending on the distribution of food and protection, the presence of predators or competitors, and body size. The better the environmental conditions, the narrower the size of the roaming area. Therefore, the basis of habitat use by primates is very dependent on the amount of food availability, the distribution of food in the habitat, and the interval of changing fruit seasons [13]. In this case the amount of feed and the availability of each feed source directly affect the size of the home range.

Tabo-tabo Education and Training Forest is a designated forest area managed under the Environmental and Forestry Education and Training Center. The area is located in Pangkep Regency and is known to be one of important habitats of M. maura in the province. However, more studies on the species have been focused on populations nearby Bantimurung areas. Only one study related with population and crop raiding by M. maura in the area [14]. More information is still required to reveal the population of M. maura in Tabo-tabo Forest. Therefore, this study aims to examine home range, activity budget, and to determine diet and resting plant species utilized of one group (named Bulu Suka) of M. maura. Findings of this study will provide baseline to support conservation-based decision making for the conservation of the species in the area.
2. Methods

2.1. Study area
Tabo-tabo Forest is located administratively in Tabo-tabo Village, Bungoro District, Pangkep Regency (South Sulawesi). The distance of the forest to the capital city of South Sulawesi (Makassar) is ± 80 km which can be reached for 1.5 hour travelling time. Geographically, the forest is situated between 118º 49' 42" - 118º 49' 45" E and 04º 40' 45" - 04º 40' 47" South. It is designated as training and educational forest under the management of Forestry and Environmental Training Center of Makassar which was established in 1980 covering 601.26 ha. The average rainfall received by the area was 3,186 mm/year ranging between 2,500-3,000 mm/year with 114 rainy days per year. Meanwhile, temperatures range from 21°C-31°C and in average, the temperature is 24.6°C. Dry months occurs between July to September and wet months are between November to May. This study was conducted from January to February 2017.

2.2. Data collection and analysis
Prior to data collection, two weeks of observation was carried out to determine the location of a macaque group observed and to habituate the group of researcher’s presence. Temporary camp nearby the group was established for easy access in observing the group the next day. To determine home range of the group, the group was followed for 6 consecutive days from 05.30 am to 19.00 pm and each daily resting stop was marked by using a handheld GPS every 30 minute. This also allowed to measure travelling distance conducted by the group daily. To identify tree species used as diet sources and resting of moor macaque (Macaca maura) in Tabo-tabo Forest, direct observation by employing 30 minutes scanning methods with 5 minutes’ interval to individuals in the group was applied. Field observations were divided into three periods: 1) morning (06.00-10.00 am); 2) noon (10.30-14.30 pm); and 3) afternoon (14.30-19.00 pm). During the observation, tree species utilized were noted. Each tree individual used as resting tree by the group was marked by using GPS. Further identification was carried out through herbarium collection if required. Apart from that, the daily activities of M. maura were also recorded. The main activities monitored were moving, resting, eating and socializing. Each day, random individual was selected, scanned, and observed during the three observation periods. Number of each activity was noted daily and calculated to gain the average.

All the data collected were input into Microsoft excel and descriptive statistics was used to interpret the data. The coordinates data of each stop were translated into a home range map by using QGIS 3.12 into polygons of daily movement. The width of daily home range was then calculated based on the outer points of daily stops made by the group.

3. Results

3.1. Daily travelling distance
There were several groups of Macaca maura in Tabo-tabo Forest, Pangkep. However, in this study only one group called Bulu Suka group observed. This group was mostly seen passing on tracking path 5 and 6 daily. Based on the daily observations to a group, there were 30 individuals in Bulu Suka group in total. As diurnal animals, all individuals in the group were active during daylight and were found some on trees and also some on the ground (below the canopy cover). Daily movement of M. maura in group generally had different patterns and travelling distance during the observation period. Total travelling distance made by the group was 6,155.6 m with the average of 1,025.9 m daily (Table 1). The shortest route was in day 4 with only 723.6 m while the longest travelling distance was
occurred in day 3 (1,602.4 m). However, between day 4-6 there was a decrease in daily travelling distance to only around 700 m.

Table 1. Daily travelling distance of *M. maura* in Tabo-tabo Forest, Pangkep

| Observation Day | Daily travelling distance (m) |
|-----------------|-------------------------------|
| 1               | 1,084.8                       |
| 2               | 1,197.5                       |
| 3               | 1,602.4                       |
| 4               | 723.6                         |
| 5               | 753.6                         |
| 6               | 793.7                         |
| **Total (m):**  | **6,155.6**                   |
| **Average travelling distance (m):** | **1,025.9** |

3.2. Daily home range

In determining daily home range, travelling distance of each day was measured by following the observed group and the coordinate points were marked by using a handheld GPS. These data were then analysed through QGIS to visualize both travelling distance which later formed polygons. This allowed to calculate the width of home range in Tabo-tabo Forest (Figure 2). The width of home range was known by estimating the length and direction of *M. maura* movement after a map generated by the software. It was found that the average width of daily home range of Bulu Suka Group in Tabo-tabo Forest, Pangkep was around 22.06 ha.

![Figure 1](image_url). Daily home range of Moor macaque (*M. maura*) in the area of Tabo-tabo, Pangkep
3.3. Diet and resting tree species
During the observations, individuals of *M. maura* used several tree species for both diet sources and resting, there were *Anthocephalus chinensis* and *Dracontomelon dao*. While tree species used only as diet sources were *Garcinia nervosa*, *Arenga pinnata*, *Flacourtia rukam*, *Ficus* sp., *Eugenia cumini*, *Mangifera* sp., and *Ganophyllum falcatum* (Table 2).

| No | Local Name       | Scientific Name        | Diet Tree | Resting Tree |
|----|------------------|------------------------|-----------|--------------|
| 1. | Jabon            | *Anthocephalus chinensis* | ✓         | ✓            |
| 2. | Kenanga          | *Cananga odorata*      |           | ✓            |
| 3. | Dao              | *Dracontomelon dao*    | ✓         | ✓            |
| 4. | Manggis Hutan    | *Garcinia nervosa*     | ✓         |              |
| 5. | Aren             | *Arenga pinnata*       | ✓         |              |
| 6. | Lobe-lobe        | *Flacourtia rukam*     | ✓         |              |
| 7. | Dawe/copeng      | *Eugenia cumini*       | ✓         |              |
| 8. | Ficus sp         | *Ficus*. sp            | ✓         |              |
| 9. | Locong-locong    | *Ganophyllum falcatum* | ✓         |              |
| 10. | Mangga Hutan     | *Mangifera* sp.        | ✓         |              |

3.4. Activity budget
Daily activities conducted by individuals in Bulu Suka Group were observed and recorded to provide description on activity budget devoted by the group in general. The activities observed were moving, resting, feeding, and socializing. According to three periods of observation (morning – 06.00-10.00 am; noon (10.30 am-14.30 pm; and afternoon- 14.30-19.00 pm), in general the largest proportion of activities occurred in the morning and noon time was feeding (>30 times). However, in the morning two main activities recorded were moving and feeding while during the noon time were resting and feeding as most common activities (>30 times) carried out by the group (Figure 3). While number of activities in the afternoon time were almost equal with the highest noted were moving and socializing (>25 times).
In general, there were four activities identified in this study conducted by *M. maura* and these were resting, feeding, moving, and socializing. Bulu Suka group of the species had spent most of their time to feed (30.4%) (Figure 4). The proportion almost equals to moving (25.3%) and resting (24.7%) activities. Meanwhile, the less activity carried out by the group in total was socializing among the members of the group which only had around 19.6% daily. The highest socializing activities were occurred in the afternoon time.

Figure 2. Activity Budget of *M. maura* in three observed periods (morning, noon, and afternoon time) in Tabo-tabo Forest, Pangkep

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Figure 3. Percentage of daily activities conducted by Bulu Suka group in Tabo-tabo Forest, Pangkep
4. Discussion
Tabo-tabo Forest in Pangkep is one of important habitats of moor macaque (*Macaca maura*) within the complex of Maros-Pangkep Karst Area. The forest is categorised as secondary forest area. The daily movement pattern of Bulu Suka group of *M. maura* in the area usually started in the morning and returned to the resting tree before dark. The minimum daily cruising distance of the group was 723.57 m and the maximum distance was 1,602.42 m (1,025.93 m). The travelling distance was relatively smaller compared to other groups of *M. maura* in other areas in Maros-Pangkep Karst Area. For example, in Karaenta Nature Reserve (Maros Regency), the average daily distance made by a group of macaque was known to be 1,070.7 m [15]. Meanwhile in the educational forest of Universitas Hasanuddin (Maros Regency), a group of macaque travelled daily around 1,590.64 m [16] and other groups in the same site reached only 1,164.54 m daily [17].

Shorter daily travelling distances in Bulu Suka group as also shown in other primates which could be related with food abundance and availability [13,18–20]. The conditions of Tabo-tabo Forest as secondary lowland forest with the width of more than 600 ha, had provided large number of plants to grow on fertile alluvial (30%) and Mediterranean red (70%) soils originated from tuff and volcanic alkaline rocks [20]. These combinations have enabled high diversity and abundance of plants that served as important food sources and shelter provision. This also indicates that the availability of food in the Tabo-tabo can be considered as sufficient so that this group of animals did not have to travel too far to find food. During observation, it was seen that the *M. maura* of Bulu Suka group mostly spent more time eating and resting on the foraging tree which have contributed to shorter travelling distance and smaller home-range. Jiang [21] and Xu [22] had found in their studies that plain forest may support higher plant species diversity with larger tree size and denser canopy cover than the one in mountainous forests due to differences in water and soil availability. This was also in line with the finding found by [16] at karst forest of Bantimurung-Bulusarung National Park where karst plain forest in lower areas, had higher chances of feeding activities made by the macaques and thus, spent more time in for feeding compared to macaques found in karst tower forest. Larger home range and farther travelling distance may indicate the rarity of food sources where the animals had to spend more time moving to forage [23]. However, differences in home ranges and travelling distance between regions at the above studies might also be occurred depending on the months when the data being collected at each location.

Seasonal variation of home ranges can be influenced by seasonal availability of food sources that differed between rainy and dry seasons [20,24]. Thus, this would affect the size of home ranges made by the group. The width of home range in Tabo-tabo was around 22.2 ha which was recorded in January to February 2017 while the peak of rainy season occurred in December with higher chances of rainfalls. The average rainfalls in January were reported to be 552 mm$^3$ and went down to the average of 385 mm$^3$ in February with number of rainy days around 15-20 days. During the home range study (February), the rainfalls usually fell in the evening and the amount of rain as not as much occurred in the beginning of observation. This has increased the chances of the group to find more food in the forest in the daytime. This compounded with the findings in other areas [5,16,20] where the home range of *M. maura* were less than 30 ha even though this involved unclear data of dry and rainy seasons (September to February) in each of the study sites. However, impact of the seasons on the availability on food resources and distance were pronounced in the findings where less efforts required where the foods were abundant and therefore, have contributed to smaller size of home range.

Finally, this will also allow differences in activity budget allocated by the macaques to forage/move and feed, rest, and socialize. During the dry season, food became rare and the group of macaques had to spend more time foraging and moving and thus, the home areas would be expanded as well as the percentage of moving activities would be higher than others [20]. High abundance of food in Tabo-tabo had also made the group being able to dedicate more time to feed (30.4%) in particular in the morning to noon time. In Tangkoko-Batuangus Nature Reserve, similar for *M. nigra*, feeding and foraging had around 28-34% and 18.7% for moving and 28.65% for resting of daily activities [25,26]. This, in consequence, has indirectly influenced the proportions of other activities.
where limited time given for other activities such as socializing. In Tabo-tabo, social activities of Bulu Suka group mostly occurred during the afternoon time approaching the evening time. Unfortunately, there were no specific observation made for social activities during the study. However, a study on social interaction of M. maura in Lejja Natural Tourism Park (Soppeng Regency) had revealed that playing was the highest percentage of social forms for the species which mostly occurred in all life stages particularly in the juveniles (62.02%) while grooming only 37.98% [27]. The time spent on various activities is a reflection of how animals balanced existing energy settings with living arrangements. In the future, there should be a detailed research on the behavioural aspects of M. maura in Tabo-tabo Forest in order to provide a clear description of bio-ecological aspects of the species.

Species of plants identified to be both consumed and used as resting trees in Tabo-tabo Forest were Antocephalus chinensis and Dracontomelon dao. In a group of M. maura inhabited Lejja Tourism Park, the common trees selected as resting trees were Delonix regia, Aleurites moluccana, and Artocarpus odoratissimus [22]. As most resting or roosting trees utilized by animals, strong tall tree with lateral branches seemed to be preferred as it could provide safety to the animals from risks of predator. Meanwhile, other diet plant species commonly eaten by the group were various species of Ficus as one of main food sources not only in Tabo-tabo [5] but also in other sites [28]. Similar with a study conducted by Labahi [15], apart from Ficus sp., other common plant consumed by the macaques were Mangifera sp.

As other moor macaques in Sulawesi, the macaques in Tabo-tabo Forest have also known to be pests and encroached some crops of the local community [3,14,28]. Labahi [14] have reported several crop raiding incidents occurred in Tabo-tabo Forest Area which have caused losses for the surrounding farmers. It was calculated that one attack had created 103,000 rupiahs loss per 0.3 ha of the land. The incidents mostly happened daily during harvesting period. However, in the observation period, Bulu Suka group had no indication of visiting community’s gardens. This could be due to the abundance of feeding sources around the observation area or the unavailability of agricultural crops because the harvest season has not yet started.

5. Management implication

Problems will later emerge once the food availability and sources are scarce where the macaques will make a shortcut by raiding local people’s lands in particular in some areas where human and animal’s habitat overlapped. Further research is required in Tabo-tabo to portray diversity of both diet and resting plant species including their abundance and availability in the forest throughout different seasons. Securing the food source and availability inside the forest will avoid human-wildlife conflicts. And therefore, habitat protection and enrichment are mandatory to sustain the resource availability for the macaques in the area. As also suggested by Morrow et al [29] conservation strategies for bridging human-macaque’s conflicts should concentrate on harmonizing both human and animal’s requirements by analysing fundamental problems and addressing the needs of both parties. Conducting monitoring on human activities, providing continued conservation education programs for local people and community, and managing habitat of macaques in Tabo-tabo Forest will ensure the conservation of moor macaque as an endemic and endangered species.

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