Ranging Behavior of Long-Tailed Macaques (*Macaca fascicularis*) At Kuala Selangor Nature Park

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***Abstract*—**This study is about the ranging behavior of a group of long-tailed macaques (*Macaca fascicularis*) that inhabit the area near Kuala Selangor Nature Park, Selangor, Malaysia. The data on ranging behavior were collected almost daily through scan sampling from February to December 2011 on all significant individuals in the focus group. Observations were focused on the moving distance and usage of canopy level by the study group in the exploiting habitat. They were more often traveled in the range between 100 and 600 m per day, and the ranging patterns were influenced by the food distribution, sleeping site, predation and also territorial factors. The study group seems to use areas that are close to human settlements because of the availability and high distribution of food. The study group does not seem to move far from their home range because they typically return to the trees along the roadside to sleep. Avoiding predators and territorial factor are the main reasons they are using the same sleeping sites. The most frequent forest canopy strata used by the study group are the ground level (36.78%), followed by the lower canopy (35.46%), middle canopy (17.93%), upper canopy (7.74%), and the lowest is emergent (2%). Overall, ranging behavior of the study group is not only influenced by food distribution but also by other factors such as avoiding predators and territorial factor at the study area.

***Keywords*—**Long-tailed macaque, *Macaca fascicularis*, ranging behavior, Kuala Selangor Nature Park, Peninsular Malaysia.

I. Introduction

As a result of habitat loss due to logging, development activities and forest conversion for agriculture coupled with the presence of anthropogenic food resources has created a situation in which the behavior and ecology of the monkeys are more affected by anthropogenic factors. One of the central pursuits in behavioral ecology is ranging behavior where it shows the manner of individuals and groups struggle to obtain, utilize, and defend their home ranges [1]. The ways primates respond towards their environments varies widely. In order to measure ranging behavior, this research has typically focused on two measures: the annual home range and daily path length. Home range refers to areas that are most frequently used [2], measured using a variety of techniques, and can be interpreted conceptually or operationally [3]. Concept model of an animal home range focused on familiarity and usage. Operating model may accurately reflect an individual's cognitive map, which includes all areas that an animal has traveled and can be an important consideration for conservation managers. However, both of these models reflect the demographic and ecological conditions which are important for a better understanding of how animals adapt to the environment [1] and may help explain the development of cognitive map [4]. In addition, an understanding of how animals move through their habitat can help us to fully understand the way they conceive and perceive their world [3]. A more concrete concept related to daily path length is how far the animal can tell us about the way individuals and groups have to navigate through their environment. It is often represented as an average or mean length moved throughout a day. Furthermore, although daily path length may reflect more immediate circumstances that prompted the movement of animals, many social and environmental conditions that affect daily path length also affect home range. Many studies have aimed to better understand these conditions.

Long-tailed macaques (*Macaca fascicularis*) are one of the most widespread primates, occurring in a broad variety of habitats where they are highly opportunistic omnivores [5], [6], [7], [8]. They frequently exploit areas influenced by human settlements and agriculture, often adjacent to the natural forest [8], [9], [10], [11]. In Peninsular Malaysia, long-tailed macaques can be found throughout the mainland, from the beach to the top of the mountain, mangroves, primary and secondary forest, isolated patches of woodland in built-up areas, orchards, plantations, and fringing forests [12], plus nowadays they can be easily found in urban areas [13]. Among the places that macaques are easily found in Peninsular Malaysia are at the tourist areas such as Bukit Malawati Kuala Selangor, Templer Park Kuala Lumpur, Penang Botanical Garden, Taiping Lake Garden and Kuala Selangor Nature Park. Long-tailed macaque population in Kuala Selangor Nature Park is distributed mainly along the road at the entrance of Kuala Selangor Nature Park [14], [15] where this area is very close to urbanized areas. According to [16], 50% of long-tailed macaque population which is living near the road and human habitation earn their food from anthropogenic food sources. Almost every day food was provisioned by humans to the monkeys in this study area, either directly or indirectly (inadvertently) through leaving of food items within their reach, such as in garbage bins near to the ticket counter of the local train station. Thus, more food was provisioned by humans during public holidays because more tourists came to Kuala Selangor Nature Park during this period [14], [15].

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II. Materials And Methods

A. Study Area

The study group was followed from February to December 2011 in the anthropogenic habitats, along the road in front of the Kuala Selangor Nature Park, Selangor, Malaysia (101° 14.678'E, 03° 20.335'N) and including the roads in residential area and small town (Fig. 1). Along the road in front of the KSNP, there are several species of large trees such as *Ficus microcarpa, Ficus tinctonia ssp. Gibbosa, Arenga pinnata, Terminalia cattapa, Muntingia calabura, Acacia auriculiformis, Areca catechu, Bambusa* sp., *Cascabela thevetia, Crytostachys renda, Elaies guineensis, Gymnostoma* sp., and *Lagerstroemia tomentosa* while the species of trees in residential area are mainly composed of *Mangifera indica, Musa* spp., and *Artocarpus heterophyllus*. All of these trees are food item that the study group obtains from their habitat. The landform in the study area is horizontal at the road and residential area while there is a slight slope because the study area is located near Bukit Malawati, Kuala Selangor. The study area is so close to a residential area which is just a few meters away. As a result, there are a variety of human activities such as walking, jogging, exercising, riding, trading, and feeding of the monkeys. Provisioned item offered by the human to the study group mostly consists of fruits such as mangoes, bananas, langsats, apples and oranges. In addition, breads, nuts, snacks and sweets were also given by the human to the study group. Apart from a few high and large-sized trees, there are also electric poles and cables between the electric poles which are often used by long-tailed macaques to move from one place to another. The long-tailed macaques in the study area were more likely to be moving on the road.

B. Ranging Data Collection

Collections of data on the ranging behavior were obtained by using Instantaneous Scan Sampling Method [17], [18], [19]. These data are related to the horizontal movement of the study group that always stays along the roadside in the daytime at the study area. It was done during the scan every 10 minutes interval by marking the daily movement patterns [17], [18], [19], [20]. The data was then used to draw the exact movement path of study group in mimeographed map of the study area. The study group was followed starting early in the morning (0800 h) at their sleeping site and ending at another sleeping site in the evening (1830 h). All of the sleeping sites were identified, marked and mapped via a Global Positioning System (GPS). Vertical movements of the study group were also recorded in each area they went through by using the same method. Height records were classified into five strata of the forest canopy as shown in Table I. During data recording of this vertical movements, height of members of the study group from the ground was estimated. The data were then analyzed using Chi-square, χ^2 Test [17], [19].

TABLE I
CLASSIFICATION OF TREE HEIGHT ACCORDING TO FOREST CANOPY STRATA (ADAPTED FROM [21])

Canopy Strata	Code	Height	Description
Emergence	EM	More than 36 m	Crown of the forest formed by a number of tall trees.
Upper Canopy	UC	26-35 m	The highest forest strata formed loosely by interconnected tall trees crown.
Middle Canopy	MC	16-25 m	Middle forest strata formed by tightly enclosed trees crown of medium sized trees.
Lower Canopy	LC	6-15 m	Lower forest strata formed loosely by sparsely distributed small trees crown.
Ground Level	GR	0-5 m	Ground level including stream and river banks and understory vegetation consists of herbaceous trees and bushes.

C. Focal Group

Selection of the study group was made during the Preliminary Observation. Results from preliminary observation has discovered a group that was often found in front of the KSNP entrance and often was hovering over the neighborhood and the nearby town searching for food and doing disturbance activity. The group is easily approached by the researcher and the people where even sometimes there were people seen giving food to the group or they asked for food from the people. Even so, this group was found to be vigilant of the threat of predators such as dogs. The study group consisted of about 41 individuals. This group has been marked by their alpha-male that has a shorter tail compared with the other group members. According to [22], the macaque groups were classified according to the unique characteristics of each individual, the alpha-male and their ranging area. Therefore, this group was selected as the main study group.

III. Results

A. Daily Ranging

Following the study group during the day has provided detailed information on ranging patterns covering their daily journeys of the study area. Study group was followed from dawn to dusk where their daily motion of the study group varies from time to time. Data on day length distance were categorized into 100m intervals to obtain the duration frequency of the day according to that classification. Daily movement patterns of the study group showed that they prefer to travel in a short distance and near the study area. They are more often travelled in the range between 100 and 600 meters per day.

Movement patterns and utilization of resource space horizontally by the study group are shown in Figure 1. It is found that the study group prefers the areas that are close to the forest edge, housing area and town area. They were found to use their home range regularly throughout the study period starting from the entrance of the KSNP to the train ticket

counter as shown by the pattern of repetitive usage that eventually have been marked by them as their main areas. In the study area there are also several types of trees frequently visited by the study group which is *Ficus microcarpa* and *Ficus tinctonia ssp. Gibbosa*. The fruit from these trees is a favorite for them. However, the study group that fed more on anthropogenic food spent less time feeding on natural fruits and flowers. These differences could relate to the higher availability of anthropogenic resources and lower availability of natural resources in the home range of the study group.

B. Distribution of Night Sleeping Sites

During the study, some of the sleeping sites of the study group were identified at the study area. The sleeping sites were marked based on the findings of the study group in the morning when the study begins and also in the evening where the study group stops at the last place to sleep. Sleeping locations of the study group was near to the place where they usually find their food and was easily predicted by the researcher. Sleeping sites of the study group usually focus on the big and tall trees especially the *Ficus* species that are found in large number at the study location. This is to protect themselves from being eaten by the predator that is usually active at night.

The study group strictly chooses and enters their sleeping site at dusk, for only there are a few sites were used repeatedly (Fig. 1). Besides, the study group will avoid sleeping at unusual or unknown places. This shows that the study group has low flexibility in the context of choosing their sleeping sites. It was found that this study group will not share their sleeping sites with another group of monkeys and also other species which is the lutong (*Trachypithecus cristatus*) that is also found at the study locations.

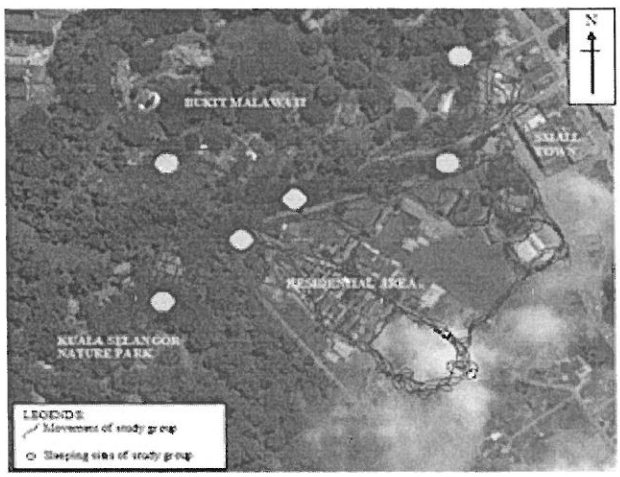

Fig. 1 Map of the study area showing movement pattern and distribution of sleeping sites of the study group.

C. Use of Different Forest Canopy Strata

The usage of the stage canopy by the study group is very much dependent on the structure and forest composition in an area. Record of the canopy usage by the study group is shown in Figure 2. It is found that the study group mostly prefers to use the ground level (36.87%) followed by the lower canopy (35.46%), middle canopy (17.93%), upper canopy (7.74%) and the very least at the emergent trees. It is found that the study group rarely chooses the emergent trees where they only exist based on the records at that level which is only 2%. Chi-square test demonstrated that the ratio of the usage at the trees canopy level by the study group are considered to be different ($\chi^2 = 4506.201$, df = 4, $p < 0.0001$).

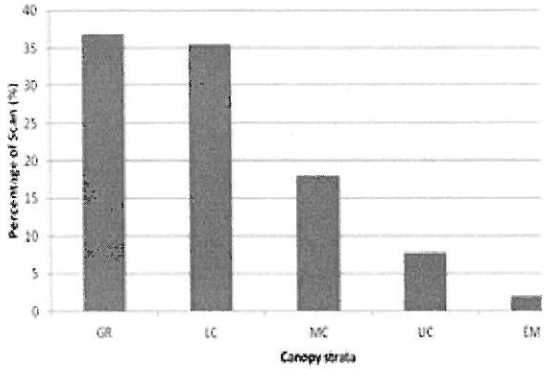

Fig. 2 Pattern of canopy use by study group.

IV. Discussion

Long-tailed macaques are social animals that travel in groups. This is to ensure that members of the group can easily hear the vocal warnings if there are predators in the environment [14]. For the mothers of long-tailed macaques, they are found to carry their baby when in moving process and always control them while playing for ensuring the safety of their baby [23], [14]. They often do daily activities together such as moving, feeding, resting, grooming, playing, vocalization, mating and fighting [14]. Movement is the most important daily activity done by the long-tailed macaques compared with other activities throughout the day [24], [25], [23], [14]. Following the study group during the day has provided detailed information about their daily travel in the study area. Daily movement patterns of the study group shows that they prefer to travel in a short distance and near to the study area. Such effects reflect the higher nutritional content and accessibility of anthropogenic food resources. This matched with a study conducted by [26] which states that the average daily movement of long-tailed macaques in the high anthropogenic (1.80±0.13 km) and in the low anthropogenic (1.48±0.10 km).

During the study period, the favorite spot for the study group to perform daily activities such as feeding, resting, grooming, sleeping and others is at the edge of KSNP starting from the entrance to the train ticket counter [14] and the nature park is surrounded by residential areas and urban areas, the study group include both nature park and urbanized areas in their home range. The preferable habitat for the study group can be seen by the most frequent usage and used repeatedly as shown in Figure 1. Many studies have indicated the relationship between daily journeys with the food availability patterns. Usually, primate will have long distance journey because of the shortage of food availability for a long time [27], [28], [29], [30]. For example, [31] found that *Macaca fuscata* in Japan were reported in doing a long distance journey from its habitat of origin during long winter because of

the shortage of food. [32] found that food-enhanced capuchins maintained a much larger territory than wild conspecifics. [33] found that crop-raiding orangutans traveled further on days when they raided crops than on days when they consumed only wild fruits. Similarly, [34] reported that chimpanzees increased their traveling and feeding time on days when they crop-raided. Compared to their wild counterparts, food-enhanced primates often have smaller home ranges and shorter day ranges, and spend less time traveling and feeding and more time resting [35], [36], [37], [38]. These various patterns highlight the complexity of primate ecological responses to food enhancement, which may depend on species and individual group and site conditions [32], [34].

However, our results slightly differ from the results for wild counterpart above where it was found that the study group who live at the forest edge and closer to human settlements (anthropogenic area) have smaller home ranges and shorter daily ranging distances and the study group spend more time moving rather than resting. This study also supports research conducted by [26] which states that, in the high anthropogenic group, they spent less time resting and more time moving. The difference in the activity budget and home range could reflect the nature of food sources available to the macaques in this study and how they utilized them. In this study, it was found that the main food for the study group composed of anthropogenic food sources (food at residential areas, garbage cans at the study location and also food that is frequently given by human). Anthropogenic food sources for primates include plantation crops, human habitation, waste depository sites, and direct human provisioning [35], [38], [39], [40], [34], [41]. The inclusion of human food sources has significant effects on the ecology of many primate species [42], [43].

In addition, other factors that influence the study group movement pattern are selection of sleeping site at night. Sleeping sites of the study group usually focus on the big and tall trees especially the *Ficus* species that are found in a large number at the study location. This is to protect themselves from being eaten by the predator that is usually active at night. During the study, it is found that the number of sleeping sites used by the study group is only a few and very limited at the study site (Fig. 1). Besides, the big size of the study group which is around 41 in numbers consist of different ages and sexes [15] also play a major role in influencing the limited sleeping site. Larger group had limited number of sleeping sites and used it repeatedly [44]. This shows that the study group has low flexibility in the context of choosing their sleeping sites. It is found that the choice of sleeping sites is also one of the strategies for not wasting their energy to move for long distance to find new sleeping sites. Besides, according to [45], the choice for not wasting its energy shows that the group will not have the problem with the predators by sleeping at the new sites. They will avoid sleeping at unusual or unknown places. This is one of the ecological aspects or an important strategy that is used by the study group to succeed. This is maybe because of the territorial factor and also to avoid any form of competitions and fights.

Long-tailed macaques are arboreal animals where they also use the level of canopy trees to move vertically. So, other than horizontal movement, they also need a vertical movement to use every stage of the canopy trees for eating, resting, grooming, sleeping, shading, and also protecting themselves from the predators. Vertical movement allows the primates to explore the different height of trees that supply different source of food [46]. The usage of the stage canopy by the long-tailed macaques is depending on the structure and forest composition in an area. In this study, it is found that the study group spends most of its time at ground and lower canopy compared to other level of canopies. This is very dependent on the habitat environment of the primates. The main food choices of the study group are food waste in the garbage cans, the food given by humans and the food from the residential areas nearby which have made them revolutionized the use of the ground level compared to other levels of the tree canopies.

Overall, the study on this ranging behavior have been successfully identified in all the daily routes of the study group and these routes are closely related with the pattern of food distribution at the study locations. Human activities such as feeding the macaques, throwing litter everywhere and not maintaining cleanliness in their residential areas are key factors in influencing their wide range of movements and disturbing people. Therefore, it is proposed so that enforcement should be conducted by suing any party found to blatantly sell or feed the macaques and do not maintain cleanliness of their home area. This has been practiced in Singapore. In addition, agencies such as Universities, Wildlife Department and Non-Government Organization should initiate awareness programs for the local people nearby and also for the tourists. Public awareness campaigns such as giving talks and creating more signboards such as "Do not feed the monkeys" and "Do not litter". Besides, the absence of predators or biological control also causes the movement of study group without limits. Therefore, it can be observed that the macaques were afraid of the presence of dogs at the study area. Thus, it is highly recommended that the authorities can create a "dog patrol units" where the dogs had been trained to control and drove the macaques from disturbing the residential areas and tourist attraction areas. Finally, study on this ranging behavior of long-tailed macaques has to be continued in the future because they have a very high ability to adapt in the residential areas or disturbed habitat.

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