



Research Article

Social Hierarchy of Adult Male Long-tailed Macaques (*Macaca fascicularis*) in the Madya Area of Pura Agung Pulaki, Bali

*Hierarki Sosial Monyet Ekor Panjang (*Macaca fascicularis*) Jantan Dewasa di Area Madya Pura Agung Pulaki, Bali*

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Abstract: Long-tailed macaques (*Macaca fascicularis*) live in groups with a social structure consisting of many males and females (multi-male and multi-female), and interactions between individuals such as social activities are strongly influenced by hierarchy. This study aimed to determine the social hierarchy structure of adult male long-tailed macaques (*M. fascicularis*) and their behavioral profiles in middle area groups in the Pura Agung Pulaki, Bali. Observations were conducted using focal animal sampling and ad libitum sampling methods. The hierarchical structure was observed using three methods, namely the sociometric matrix method, food distribution, and other analyses that support hierarchical determination (non-copulatory mounting, scrotal touching, and combing between males). The highest activities in the middle area group were browsing (17.2%) and moving (17.2%). The hierarchical structure in the middle area group is ordered from the most dominant individual as follows: Ra, Co, Ma, Ku, Cha, Fra, Ka, Ni, In, and Jo. The hierarchical structure in the middle area group is linear. The provision of food bait has been proven effective in determining the social hierarchy structure in long-tailed macaques (*M. fascicularis*). This study can be used as a basis for the conservation of long-tailed macaques (*M. fascicularis*) in the Pura Agung Pulaki area.

Keywords: Adult Male, *M. fascicularis*, Pulaki, Hierarchical Structure

Abstrak: Monyet ekor panjang (*Macaca fascicularis*) hidup secara berkelompok dengan struktur sosial yang terdiri dari banyak jantan dan betina (multi-male dan multi-female), interaksi antara individu seperti aktivitas sosial sangat dipengaruhi oleh hierarki. Penelitian ini bertujuan untuk mengetahui struktur hierarki sosial monyet ekor panjang (*M. fascicularis*) jantan dewasa dan profil tingkah lakunya pada kelompok area madya di kawasan Pura Agung Pulaki, Bali. Pengamatan dilakukan dengan metode *focal animal sampling* dan *ad libitum sampling*. Pengamatan struktur hierarki menggunakan tiga metode, yaitu metode *sociometric matrix*, penebaran pakan, dan analisis lainnya yang mendukung penentuan hierarki (*non-copulatory mounting*, penyentuhan skrotum, dan selisik yang dilakukan sesama individu jantan). Aktivitas tertinggi pada kelompok area madya adalah aktivitas menelisik (17,2%) dan berpindah (17,2%). Struktur hierarki pada kelompok area madya diurut dari individu paling dominan sebagai berikut: Ra, Co, Ma, Ku, Cha, Fra, Ka, Ni, In, dan Jo. Struktur hierarki pada kelompok area madya bersifat linier. Pemberian umpan pakan terbukti efektif untuk menentukan struktur hierarki sosial pada monyet ekor panjang (*M. fascicularis*). Penelitian ini dapat digunakan sebagai dasar dalam upaya melakukan konservasi monyet ekor panjang (*M. fascicularis*) di kawasan Pura Agung Pulaki.

Kata kunci: Jantan Dewasa, *M. fascicularis*, Pulaki, Struktur Hierarki

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INTRODUCTION

Long-tailed macaques (*Macaca fascicularis*) are members of the *Macaca* genus and are widely distributed throughout the world from Morocco, Algeria, Afghanistan, China, Japan and Southeast Asia (Napier and Napier 1985). In Indonesia, *M. fascicularis* was also widely distributed from western Indonesia to East Nusa Tenggara (Muhibbudin 2005). *M. fascicularis* in Bali occurs in several separate local populations and is thought to have originated from Java. *M. fascicularis* is highly adapted to living near coastlines, along rivers, in forests up to 2,000 meters above sea level, and even near human settlements (Roonwal and Mohnot 1977), so it has a wide distribution (Eudey 1980; Fooden 1995) and has ecological, aesthetic, recreational and commercial value.

M. fascicularis lives in groups with a social structure consisting of multiple males and females (*multi-male multi-female*). The group comprises adult males, adult females, sub-adult males, sub-adult females, juveniles and infants (Napier and Napier 1967). The primary of this social group is to protect one another from predators. Each individual in a group will interact with each other consisting of social and non-social behaviors. The individual that has the highest dominant social stratum is occupied by one adult male (alpha-male). Hierarchical dominance plays an important role in preventing the escalation of aggressive behavior so that the integrity of group life can be maintained. Dominant individuals will have preferential access to resources over subordinates. Dominant status in males is often positively correlated with copulation frequency, and males of *M. fascicularis* have easier access to food, so hierarchy is often associated with reproductive success (Gursky-Doyen & Supriatna 2010; Rowe & Myers 2016).

Pura Agung Pulaki is a sacred place for Hindus in Bali also serves as a conservation site for *M. fascicularis*, and the research site is also unique in that it has a place to protect visitors who want to worship in the form of iron cages to avoid negative interactions with *M. fascicularis*. In a survey conducted in December 2023, there were five *M. fascicularis* groups in Pura Agung Pulaki, namely Pura Agung Pulaki, Pura Madya, Pura Pabean, Parkiran, and Pura Tirta. This study focused on one group area, namely the Madya Temple group area because *M. fascicularis* in this group area is more populated than the other group areas, there are 87 *M. fascicularis* in the middle group consisting of infants/infants 11 tail, pups/juvenile 6 tail, young/sub adult 45 tail, adult male / adult male 12 tail, adult female / adult female 13 tail and dominated by young macaques (sub adult). In addition, *M. fascicularis* in this area is more likely to engage in social behavior in response to visitors, and its natural behavior in this area has changed and is more dependent on humans. Interactions between individuals in madya groups are strongly influenced by hierarchical structures. This is given the different social roles of alpha-males in the group and assumed that there will be differences in daily behavior between alpha-males and other males who have lower dominance in the group. Therefore, this study was conducted to obtain data on the hierarchical structure of *M. fascicularis*, especially adult males in the intermediate group, which can be used as a basis for *M. fascicularis* conservation in the Pura Agung Pulaki area.

MATERIALS AND METHODS

Time and Location of Research

This research was conducted from March to April 2025 which consisted of site survey activities, observation and field data collection, data analysis, and report writing. The location of this research was carried out at Pura Agung Pulaki, precisely around the Madya Temple area as shown in Figure 1 which is located in Banyupoh Village, Gerokgak District, Buleleng Regency, Bali Province, Indonesia, with coordinates between -8.1454797 LS; 114.6805527 BT, an area of 1,316.65 m², and an altitude of 6.3 meters above sea level.

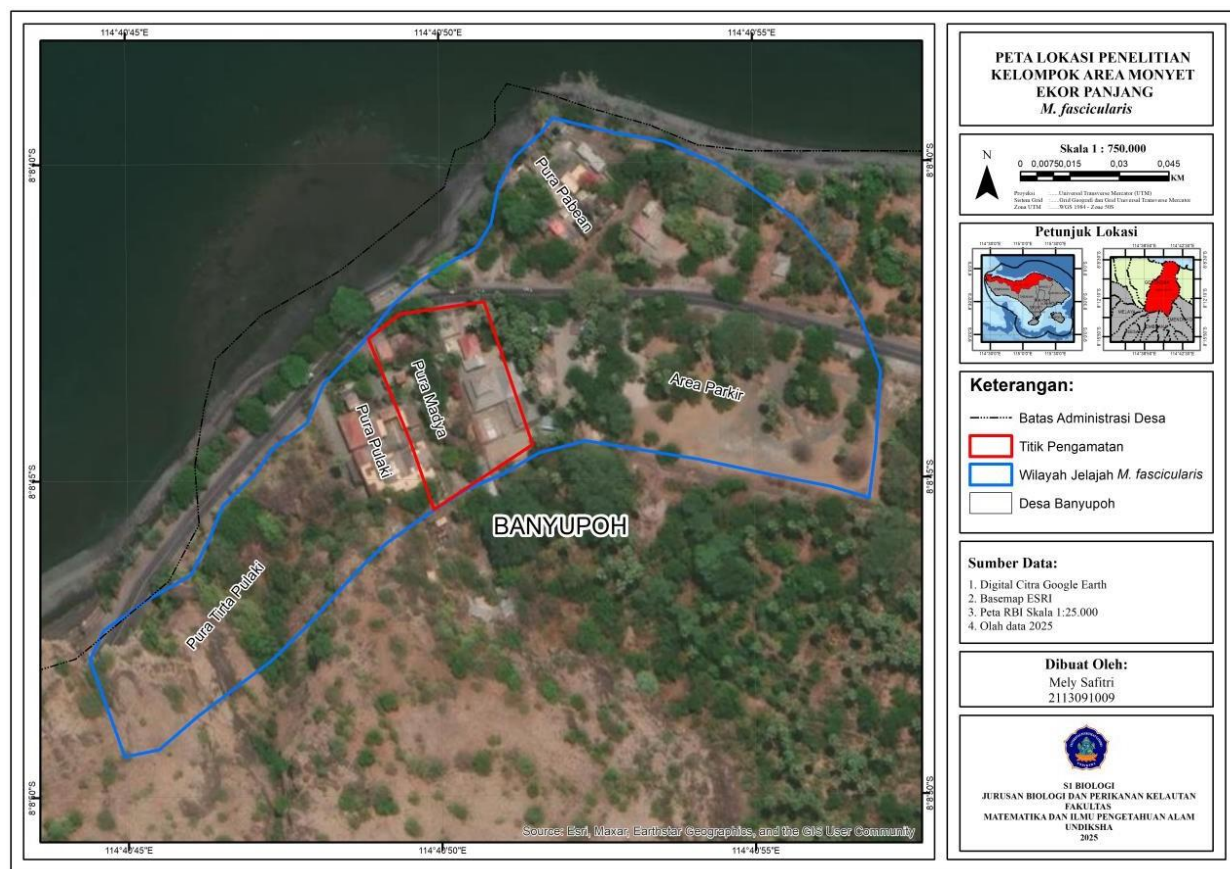


Figure 1. Research location Map(Source: personal documents, 2025)

Research Stages

This study consists of five stages, namely the habituation stage, individual observation, daily activity observation, hierarchical structure determination, and data analysis (Figure 2).

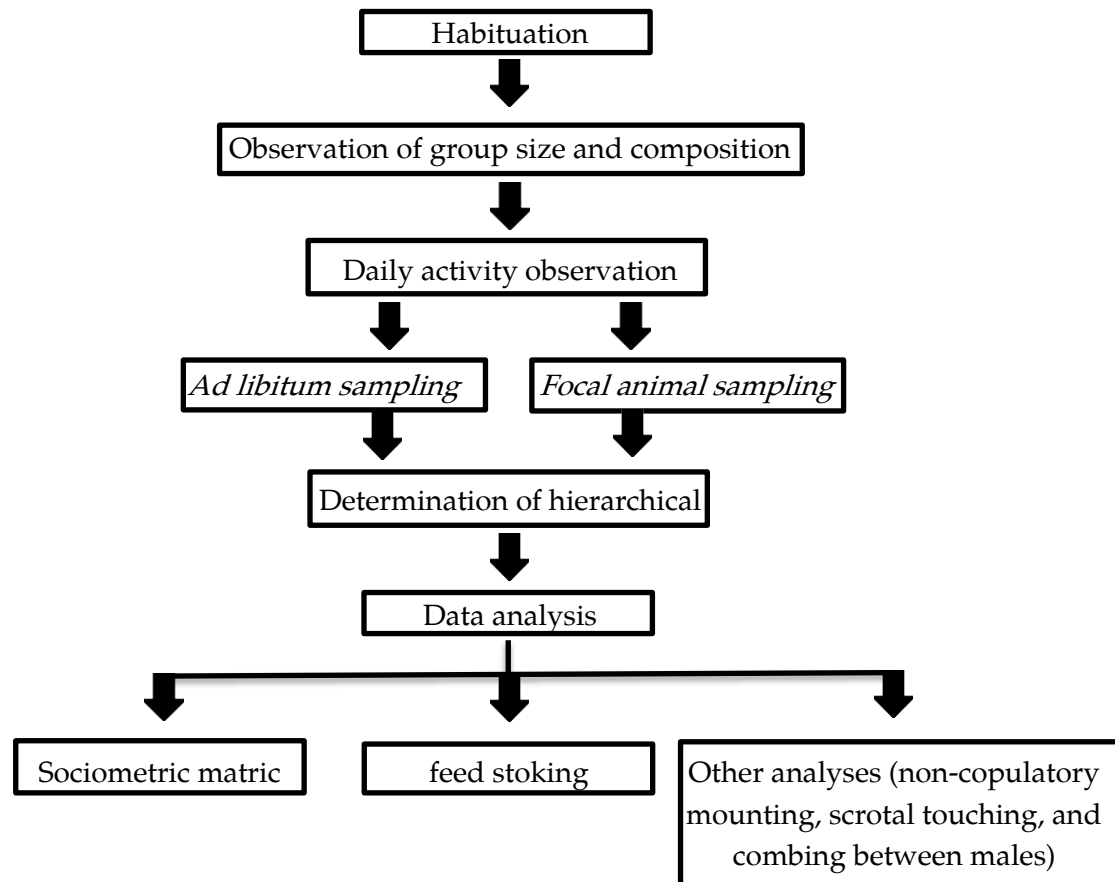


Figure 2. Research stages

Research Procedures

Habituation

Habituation was conducted to familiarize *M. fascicularis* with the presence of researchers. Observations were conducted directly for 7 days/hour and divided into two times in the morning at 08:00 - 12:00 WITA and in the afternoon at 13:00 - 15:00 WITA. At this stage, we spread food such as eggs, sweet potatoes, cassava, bananas, corn, etc., and followed *M. fascicularis* into the core area of the middle group, so that *M. fascicularis* became familiar with the presence of researchers

Observation of the number of individuals in the Madya group

Observations of the number of individuals and group structure (group size and composition) are observed directly, which is done when the group is doing activities or habits in a certain place using the collection of demographic parameters with the concentration count

method. At this stage, a feeding technique was also used so that all members of the intermediate group gathered to facilitate counting

Daily activity observation of *M. fascicularis*

Behavioral observations using the *ad libitum* sampling technique. *Ad libitum sampling* is the process of recording as much data as possible that is observed from the social behavior of the middle group, such as observations of behavior, all individuals, and the time when behavior occurs.

Daily behavioral observations are made using the *focal animal sampling* technique. Focal animal sampling is the recording of all activities specifically on one individual or group. Observations are recorded for a certain period specific to one individual, followed by recording on other individuals with the same duration. Daily recording is divided into feeding, moving, foraging, playing, sleeping, probing, copulation, and agonistic activities. The period used was 15 minutes per section and observations over 15 days with 32 sessions per day were expected to cover these activities.

Determination of Hierarchy Structure

Determination of dominant individuals is carried out by three methods, namely sociometric matrix, food stocking, and other analyses such as non-copulatory mounting, scrotal touching, and combing carried out by fellow males that support determining dominant individuals. The sociometric matrix records the frequency of behavioral interactions carried out by two individuals (dyadic interaction), with the perpetrator of the behavior recorded in the row and the recipient of the perpetrator recorded in the column. Through the sociometric matrix can be seen an interrelated individual interaction, such as the perpetrator of the attack with the recipient of the attack (Altmann, 1973). The data used in the sociometric matrix is obtained from agonistic activities recorded using the focal animal sampling technique.

Feeding is an additional technique that is carried out if the hierarchical structure is not yet clearly visible, especially in the middle of the hierarchy. The results of the food distribution will obtain a matrix of expulsion between all male individuals.

Data Analysis

Dominant individuals in the middle group were determined using three analyses: sociometric matrix, food stocking, and other analyses (non-copulatory mounting, scrotal touching and scissoring). Agonistic activity data were obtained from *focal animal sampling* data collection and then entered into the Sociometric matrix data. The highest agonistic frequency was assigned as the dominant individual (alpha-male), while the individual with the lowest agonistic activity was assigned as the subordinate individual.

Data from daily behavioral observations of *M. fascicularis* were analyzed using the formula used by Hanifa (2021), as follows:

$$\text{Presentation} = \frac{x}{y} \times 100\%$$

Description :

x = Average activity of individuals in the population

y = Total average off all individual activities in the population

RESULTS AND DISCUSSION

Group Structure of Madya *M. fascicularis*

The group structure in the Madya area at Pura Agung Pulaki, Bali. From the calculation results, the number of group members in the Madya area is 109 heads consisting of infant macaques consisting of 18 heads, juvenile macaques (11 heads), young macaques /sub.adult (55 heads), adult male macaques /adult male (10 heads), and adult female macaques /adult female (15 heads). The Madya area group was dominated by young/sub adult macaques (55 macaques) (Table 1).

This suggests that the age structure of *M. fascicularis* has good regeneration capacity (Dharmawan et al. 2005). Population growth will increase rapidly in the coming period due to natality also known as breeding potential (Hidayat 2012).

Table 1. Group structure of madya group

No	Age class	Total
1	Infant	18
2	Juvenile	11
3	Sub adult	55
4	Adult male	10
5	Adult female	15
Total		109

Daily Activities

The highest daily activities of long-tailed macaques (*M. fascicularis*) in the madya area group were searching (17.2%) and moving (17.2%). The second highest activity was sleeping (16.1%). The third highest activity was foraging (11.2%). The fourth highest activity was agonistic activity (10.7%). The fifth highest activity was eating (9.5%) and playing (9.5%), and the sixth highest activity was sexual activity (8.6%). Of the eight daily activities, the determination and hierarchical analysis focused on agonistic activities.

The activity of examining and moving was the highest of all daily activities in the Madya area group. This was due to the abundance of food, which allowed *M. fascicularis* to have more time to engage in other activities such as browsing and moving. According to Wilson (1975), grooming behavior is usually performed during resting periods, when the group is in an inactive position or not doing anything. According to Ryan et al. (2016), *M. fascicularis* moves from one location to another over short or long distances to search for food sources, avoid predators, social movement (playing and grooming), seasonal migration, and territory exploration.

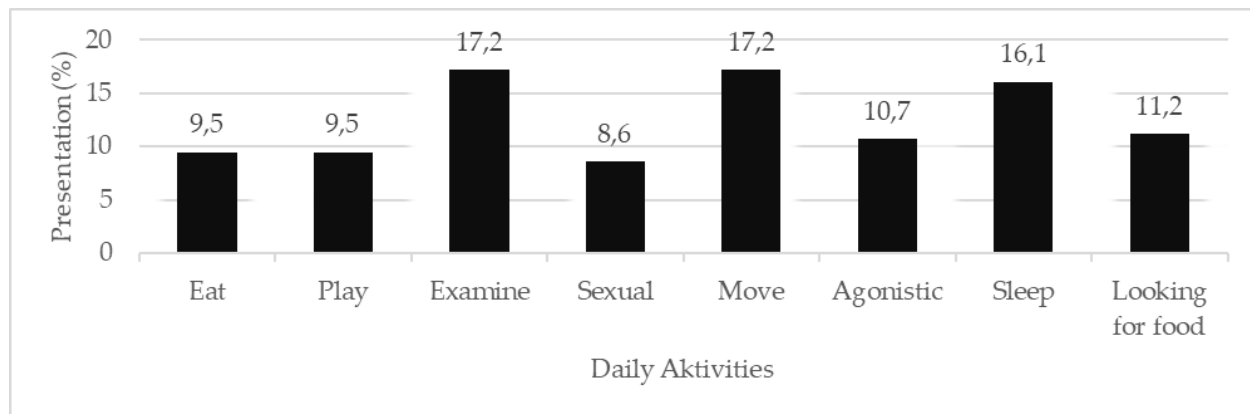


Figure 3. Daily activity of *M. fascicularis* in madya group



Figure 4. Daily activities of *M. fascicularis*; Scavenging (A), foraging (B), sleeping (C), sexualizing (D), moving (E), and playing (F). (Source: personal documents, 2025)

Agonistic Activity

Agonistic activities are divided into three more specific activities, namely threatening, attacking, and fighting activities. Agonistic activities in the Intermediate group amounted to 10.7% (figure 3). Agonistic activities in the Intermediate group were shown by threatening activities at 58.4%, followed by attacking activities at 25.3%, and fighting activities at 16.3%. (Figure 5). In the 10 adult males in the Intermediate group, the highest agonistic activities of threatening, attacking, and fighting were shown by Rafael, which amounted to 35 times, 12 times, and 7 times, respectively (Figure 6).

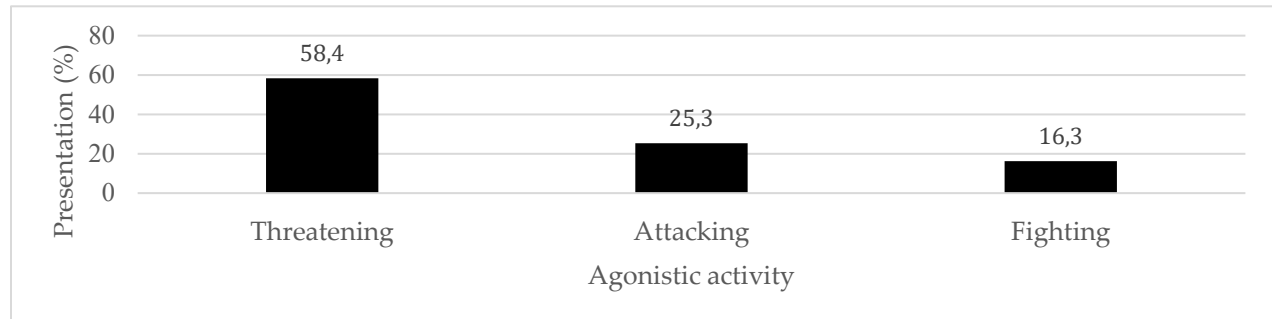


Figure 5. Graph of agonistic activity in the Madya group

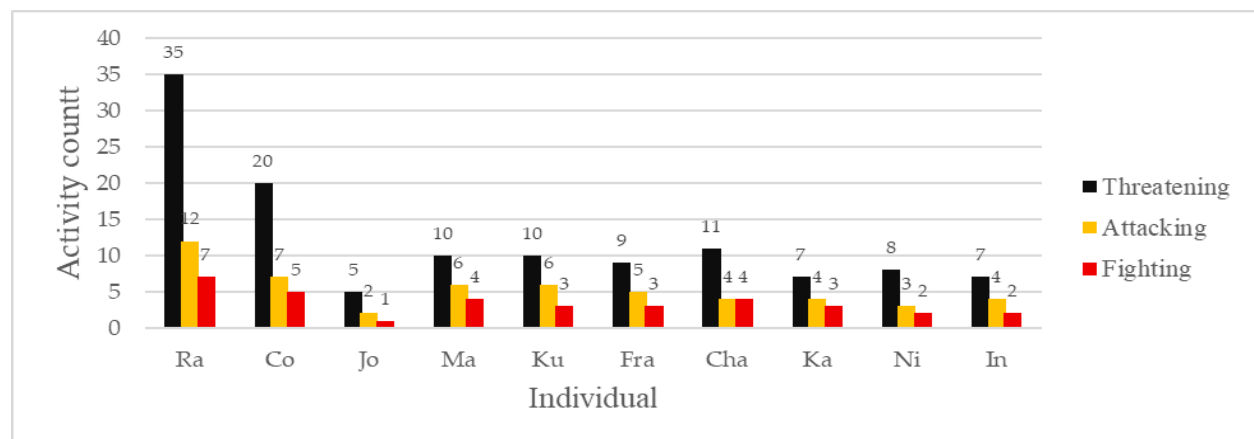


Figure 6. Graph of agonistic activity in the Madya group



Figure 7. Agonistic activities of the threatening (A), attacking (B), and fighting (C)

Response to Agonistic Activity

The response to agonistic activity is divided into two, namely grimace and retreat. In the Madya area group, the highest number of individuals in response to agonistic activity are individuals Jo and In, who grimace 20 times and 18 times respectively, while retreating 10 times and 19 times (Figure 8).

The response to agonistic activity is based on the effects of agonistic activity. The response to agonistic activities is divided into two, namely the first is grimace, arising in response to small-scale agonistic activities. The second response to agonistic activity is retreat, arising in response to large-scale agonistic activity. High-hierarchy individuals have never been observed to perform both responses to lower-hierarchy individuals. According to [Maestripieri \(1996\)](#), retreat activity is an effect of agonistic activity in *M. nemestrina* and grimace is the main submissive signal with three other activities, namely presentation and lip-smack.

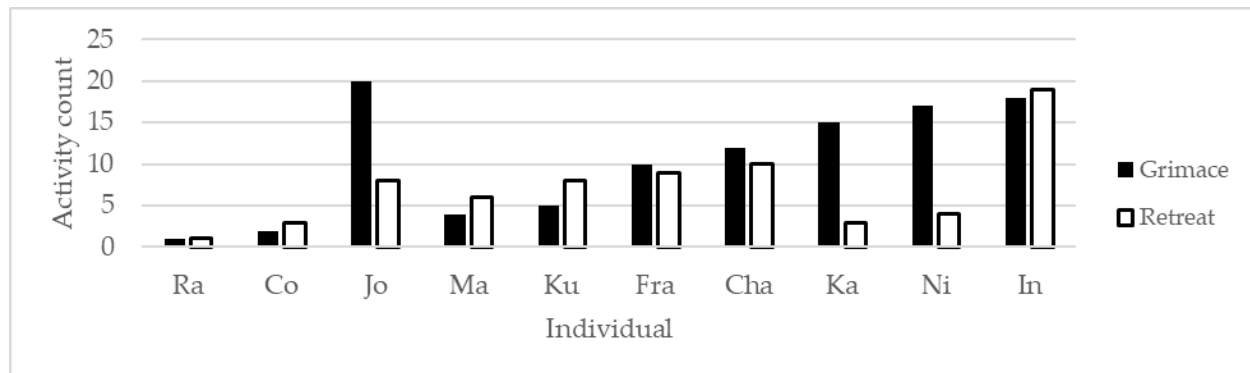


Figure 8. Response to agonistic activity

Hierarchical Structure Analysis

Sociometric matrix data is taken based on three agonistic activities, namely threatening, attacking, and fighting activities. When analysing the determination of the hierarchical structure, the data is combined into one, namely the sociometric matrix of agonistic activities. The sociometric matrix of agonistic activities (threatening, attacking, and fighting) shows that individual Ra has the highest frequency in the March-April 2025 period (Table 2) then followed by individual Co in the second position, while at the lowest position, it can be seen that individual Jo has the highest frequency in receiving agonistic activities (table 2). the middle hierarchical position is occupied by individuals Ma, Ku, Cha, Ka, Ni, and In with almost the same activity (Table 2). Therefore other activity observations are needed that support the determination of the hierarchical structure.

Determination of the hierarchical structure can be seen from the observation of three more specific activities, namely threatening, attacking, and fighting activities. According to Stahl et al. (2000), *M. silenus* divides direct agonistic activities (fighting) and indirect agonistic activities (threatening, attacking, repelling, and disturbing). Furthermore, agonistic activities were

analysed using the sociometric matrix method. The sociometric matrix method is used to look at the interaction between the perpetrator and the recipient (dyadic interaction), the type of activity, and the frequency of the activity, and vice versa (Altmann 1973), therefore the Sociometric matrix analysis has more accuracy if used to determine the hierarchy compared to the frequency count analysis method alone. According to Oi (1990), using such a matrix can reveal agonistic interactions between individuals and the hierarchical order in *M. nemestrina*,

Table 2. *Sociometric matrix* table of agonistic activities

Give Accept	Ra	Co	Jo	Ma	Ku	Fra	Cha	Ka	Ni	In	Total
Ra		0	0	0	0	0	0	0	0	0	0
Co	3		0	0	0	0	0	0	0	0	3
Jo	12	6		10	9	7	9	8	7	7	75
Ma	4	3	0		0	0	0	0	0	0	7
Ku	5	4	1	1		1	1	1	0	0	14
Fra	8	2	1	1	3		2	1	2	1	21
Cha	5	1	1	1	1	1		1	0	1	12
Ka	5	6	1	1	1	1	1		1	1	18
Ni	6	4	1	2	2	3	3	1		3	25
In	6	6	3	4	3	4	3	2	3		34
Total	54	32	8	20	19	17	19	14	13	13	

The method of determining the hierarchical structure with food stocking can be used as additional data in determining the hierarchical structure. Based on food stocking activities in the Madya area group carried out in the March-April period (Table 3) shows that individual Ra was the male with the highest dominance expulsion (100 times), the second position was occupied by individual Co with the number of expulsions (77 times), The third position is individual Ma (54 times), the fourth position is individual Ku (47 times), the fifth position is individual Cha (35 times), the sixth position is individual Fra (22 times), the seventh position is individual Ka (20 times), the eighth position is individual Ni (12 times), the ninth position is individual In (8 times). And individual Jo occupies the position as the lowest-ranked male by receiving expulsion 98 times. In this method, it will be seen that individuals with a high hierarchical structure will find it easier and earlier to get food than individuals with a low hierarchy, and a high hierarchy will expel individuals with a low hierarchical structure. According to Koenig (2002), low-hierarchy individuals in long-tailed macaques will wait until high-hierarchy individuals leave the food and eat the remaining food.

Observations of other activities that may support dominance, such as non-copulatory mounting, adult males and scrotal touching, can also be used as a reference to determine the hierarchical structure of the Madya area group. Individuals Ra, Co, and Ma were recorded to have performed non-copulatory mounting activities on individuals Ni and In, which means that individuals Ra, Co, and Ma have higher dominance compared to individuals Ni and In. In combing activities among male individuals, it was recorded that individuals Ni, In, and Jo carried

out combing against individual Ra, which means that individual Ra has high dominance compared to individuals Ku, Fra, and Cha. Individual Co was recorded to have made scrotal contact with individuals In and Jo, which means that individual Co has a higher dominance compared to individuals In and Jo. According to Oi (1990), non-copulatory mounting activity is the activity of mounting other male individuals without permission to the individual and occurs after agonistic interactions with the individual. In *M. nemestrina*, non-copulatory mounting is a process of directly lowering the hierarchy carried out by male individuals. Scrotal touching activity is the least observed activity observed between two males engaged in brief play (Maestripieri 1996). In *M. fascicularis*, same-sex flirting is a reward for high-hierarchy individuals (Gumert and Ho, 2008).

Table 3. Sociometric matrix of the Madya group at the time of feed stocking

Give Accept	Ra	Co	Jo	Ma	Ku	Fra	Cha	Ka	Ni	In	Total
Ra		0	0	0	0	0	0	0	0	0	0
Co	7		0	0	0	0	0	0	0	0	7
Jo	18	15		12	10	8	11	9	7	8	98
Ma	8	6	0		0	0	0	0	0	0	14
Ku	10	8	0	4		0	0	0	0	0	22
Fra	8	12	0	8	7		2	0	0	0	37
Cha	12	8	0	5	5	0		0	0	0	30
Ka	10	6	0	7	6	4	5		0	0	38
Ni	12	9	0	8	8	5	7	5		0	54
In	15	13	0	10	11	5	10	6	5		75
Total	100	77	0	54	47	22	35	20	12	8	

The hierarchical structure of the Madya area group can be sorted from the highest individual to the lowest individual as follows: Ra, Co, Ma, Ku, Cha, Fra, Ka, Ni, In, and Jo. Based on sociometric-metric analysis, agonistic activity, food distribution, and observations of activities that support dominance, it can be determined that the hierarchical structure of adult male *M. fascicularis* in the Madya area group is linear or straight (Figure 7). It can be said to be linear if the most dominant individual dominates all individuals in a group, the second dominant individual dominates all individuals in a small group except the first dominant individual, the third dominant individual dominates all individuals in the group except the first and second dominant individuals, and so on until the lowest individual who has no dominance in the group (Beacham, 2003).

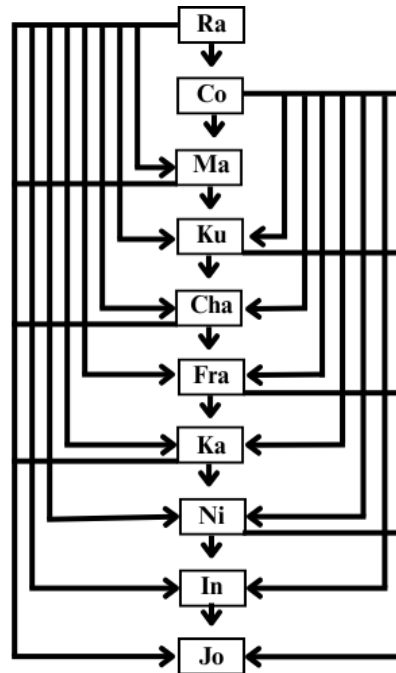


Figure 7. Hierarchical structure of *M. fascicularis* in the Madya group

CONCLUSIONS

The dominant individuals were young *M. fascicularis* (55 individuals) with high daily activity levels of grooming (17.2%) and moving (17.2%) due to abundant food availability, giving *M. fascicularis* more time to engage in other activities such as grooming and moving. The social hierarchy structure of adult male *M. fascicularis* in the middle area group was ranked from the most dominant individuals as follows: Ra, Co, Ma, Ku, Cha, Fra, Ka, Ni, In, and Jo. The hierarchical structure in the middle area group was linear. The bait-test proved effective in determining the social hierarchy structure of *M. fascicularis*.

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