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RESEARCH ARTICLE

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Daily Behaviour of Long-tailed Macaque in the Captive, Semi-wild, and Wild Habitats: Preliminary Reports

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Abstract
One of the endangered non-human primates, *Macaca fascicularis*, can adapt to various conditions of habitats, including full-housed, semi-wild, and natural habitats. This species has multi-male, multi-female social bonds that influence their daily behaviour activity. This study tried to describe the daily behaviour of *Macaca fascicularis* in their original habitats through a web-based survey. This study categorised the original habitat as captive, semi-wild, and wild. The focus of behavioural frequency data observed in all habitats includes feeding, locomotion, sleeping, grooming, playing, and aggression. This study used statistical analysis for each paired habitat. The daily behaviour for all pairs showed similar budgets, except for captive 1 and 2, which showed significant differences (p-value<0.05). Six behaviours showed no significant difference (similar frequency) in all habitats. The factors that impact the daily behaviour for each habitat include environmental enrichment and condition, natural resources, individual number proportion (group size), and response to human and anthropogenic disturbance.

Key words: Activity, Captive, Cynomolgus macaque, Endangered Primate, *Macaca fascicularis*, Tinjil.

1. Introduction

Macacafascicularis(long-tailedmacaque,LTM) have high adaptation success, so they are scattered in various habitats and live in groups, inseparable from social interactions with other individuals in their group. The social interactions carried out by LTM give rise to various activities between individuals in a population (Suwarno 2014). Social activities in the population of LTM include social affiliation, social agonism, and non-social activities. The daily behaviour of LTM who are accustomed to living in groups with specific activities affects the area of cruising, namely the area of movement to obtain food (Lee *et al*. 2012). So, the daily activity of LTM in each different habitat is exciting to study as an effort to preserve its population in its natural habitat.

The social group of LTM is female-bonded, meaning that the males will be out of the group at puberty. Thus, the interrelationship of groups seems to be lower than matrilineal (van Noordwijk and van Schaik 1987). More differences in interrelationships occur when comparing high-ranking bloodlines with lower-ranked, with higher-rank individuals closer in kinship to each other (van Noordwijk and van Schaik, 1999; Marc Luetjens *et al*. 2020; Al Hakim and Nasution 2021). In addition, scattered groups of males born to the same social group showed various interrelationships, sometimes seemingly relatives, while at other times seemed unrelated (Mishra *et al.* 2020a). The increasing size of the group leads to increased competition and the energy spent on the search for resources, especially food (Brotcorne *et al.* 2015; 2017). Furthermore, social tension builds and prevalence of interactions that reduce tensions, such as social grooming falling with larger groups (Sussman and Tattersall 1981). Thus, group life seems to be maintained solely because of security against predation (Rowe and Myers 2016). The LTM have wide distribution (Supriatna and Wahyono 2000), especially in Indonesia; unfortunately, it does not depend on the population size; which consistently decreased (Eudey *et al*. 2020; Hansen *et al.* 2021; 2022). One of the efforts to guard against primates extinction is to provide in- or ex-situ conservation areas (Malaivijitnond and Hamada 2008; Payne and Campbell 2007). Because today the IUCN Red-List reported that this species is in endangered status (Hansen *et al.* 2022).

Meanwhile, comparing the captive and wild-like habitats for those who need to study daily activity is essential to determine their welfare status. The

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factors influencing that comparison include social factors, environmental habitat (enrichment, climate, and season), group size and composition, individual differences and histories, and the captive environment (Howell and Cheyne 2019). Nevertheless, studies of LTM behaviours in different habitats (captive and wild-like) were limited. Related studies for comparing behaviours in captive and wild habitats, such as by (Forss *et al*. 2015; Howell and Cheyne, 2019); nesting, sleeping, and nighttime behaviours for great apes (Anderson *et al*. 2019). Factors that affected the primate behaviour in different habitats that were previously reported, such as environmental enrichment and group size. As reported by (Kerridge 2005), environmental enrichment would address behavioural differences between Prosimian captive and wild. Besides, group size is also implicated in captive and wild behaviour behaviours (Price and Stoinski 2007). Based on these explanations, the purpose of this study was to compare the behaviour of LTM residing in the wild, semi-wild, and captivity (fully-housed).

2. Materials and Methods

2.1. Literature Compilation

Between December 2021 and March 2022, we conducted an online-based survey of studies on the daily behaviour of the LTM using scientific databases, such as Google Scholar (https://scholar.google.com), Lens (https://www.lens.org), Dimensions AI (https://www.dimensions.ai/), IPB Scientific Repository (https://repository.ipb.ac.id), University of Indonesia Repository (https://lib.ui.ac.id/), and repositories of other universities. The sources include academic reports, thesis, and book chapters (written in English and Indonesian). We used the keywords for captivity studies' *activity budget OR daily activity OR daily behaviour OR social behaviour OR feeding behaviour AND long-tailed macaque OR cynomolgus macaque OR Macaca fascicularis AND captive OR zoo OR housing OR caging OR harem OR grouping OR laboratory*', for the semi-wild and wild habitat we used '*activity budget OR daily activity OR daily behaviour OR social behaviour OR feeding behaviour AND long-tailed macaque OR cynomolgus macaque OR Macaca fascicularis AND semi-captive OR semi-zoo OR tinjil OR wild OR forest OR national park*'.

2.2. Standardisation of Behavioural Data

We used *raw data* on the frequency of behavioural observation in the captive (Indrarini 2015; Fachrozi and Setyawatiningsih 2020), semi-wild Tinjil Island (Suwarno, 2014), and wild habitat (Al Hakim *et al.* 2022). We also have the agreement from each researcher for using the *raw data*. In the case study by (Al Hakim *et al.* 2022), although this study focused on alpha male focal animals, we obtained complete *raw data* for all individuals in the study group of 73 individuals for all behaviours studied. We focused on all the behaviours observed in all habitats, such as feeding, locomotion, sleeping, grooming, playing, and aggressive behaviour. Table 1 describes the source of the observational data on the LTM behaviour used in this study.

Based on Table 1, each study used as a source of behaviour observation data consists of various numbers of individual subjects of research, the number of groups, and methods of behaviour observation, so that the data used as a reference is the average of each behaviour in all habitats (captivity, semi-captivity, wild) and the individuals focused on are all animal subjects observed for each behaviour in each study. Although, in the cases of captive 1 and captive 2, the data shows different individuals' numbers, sex, and age, so it was probably different in the behavioural things.

2.3. Data Analysis

The average behaviour data were then carried out statistical analysed with (1) paired t-tests to obtain the p-value value of each two habitat pairs for all feeding, locomotion, sleeping, grooming, playing, and agonistic (aggressive behaviour) so that a comparison between the two habitats for all behaviours was obtained; (2) the t-test by categorising the habitat in Table 2. We assumed that captive 1 (Fachrozi and Setyawatiningsih 2020) and captive 2 (Indrarini 2015) is an artificial habitat with the aim of ex-situ captivity. Meanwhile, in semi-captive Tinjil (Suwarno 2014) and wild (Al Hakim *et al.* 2022) is a natural habitat that is native without being human-made.

Once the habitat is categorised, statistical analysis with the various t-tests described earlier assumes the same diversity value for each habitat (captivity is an artificial habitat; Tinjil and the wild are natural habitats) to obtain the p-value of every two behavioural pairs for both habitat categories. Besides,

Table 1. The source of the observational data on the LTM behaviour for this study

Habitat	Subject Observed	Sampling Method	Source
Captive 1	Two troops (A: n=9, B: n=4, ∑=13)	Focal animal sampling and ad libitum sampling	(Fachrozi and Setyawatiningsih 2020)
Captive 2	Four troops (Joni: n=19, Pop: n=8, Heineken: n=17, Coki: n=23, ∑=67)	Scan instantaneous sampling and ad libitum sampling	(Indrarini 2015)
Tinjil	The nearest troop from the base camp (probably M26 Troop (Kyes, 1993; Leeson, Kyes and Iskandar, 2004; Purbatrapsila, Iskandar and Pamungkas, 2012) with n=55 (Kyes, 1993))	Scan sampling	(Kyes 1993; Suwarno 2014)
Wild	One troop (Jona: n=∑=73)	Focal animal sampling*	(Al Hakim *et al.* 2022)

*Note: studied by (Al Hakim *et al.* 2022) was done with all of the research assistants, and each of them focused on one age group (adult male, adult female, pre-adult male, pre-adult female, juvenile male, juvenile female, and infant)

Table 2. Habitat categorisation for this study

		Habitat			
Origin Habitat	Research	Captive 1	Captive 2	Semi-Captive (Tinjil)	Wild
Categorised As		Artificial		Natural	

comparing two habitat categories for all behaviours with p-values was compared to compare behaviour in artificial and natural habitats. This p-value test can determine the degree of difference in significance to behaviour.

We propose the pairs categorisation for the statistical test, and there are Pair 1 (captive 1−captive 2), Pair 2 (captive 1−Tinjil), Pair 3 (captive 1−wild), Pair 4 (captive 2−Tinjil), Pair 5 (captive 2−wild), and Pair 6 (Tinjil−wild).

3. Results

Table 3 is the result of paired t-tests for 6 habitat pairs (captive 1−captive 2; captive 1−Tinjil; captive 1−wild; captive 2−Tinjil; captive 2−wild; and Tinjil−wild) on all observed behaviour.

Table 4 is the result of the t-test for each behaviour (feeding, locomotion, sleeping, grooming, playing, agonistic) in the category of artificial and natural habitats.

4. Discussion

Regarding the statistical results in Table 3, the only significant difference (p-value<0.05) is the habitat pair of Pair 1 (Captive 1–Captive 2). Although based on the origin breeding of LTP in Captive 1, used for academic or scientific purposes at Riau University (Fachrozi and Setyawatiningsih 2020), the type of captive is outdoor. Meanwhile, in Captive 2, based on the origin of the dancing monkey (*topeng monyet)* confiscated, which is related to stereotype behaviour findings (Indrarini 2015). Pair 1 shows a significant difference because influenced by environmental enrichment and intrinsic condition (Gottlieb, Maier and Coleman 2015); as already known, these factors influence how they behave (Trollope 1977; Wolfensohn and Honess 2008). Also, (Jaman and Huffman 2008) reported that the captive condition depended on the enclosure environment that affected the activity budget of primates. Captive 1 is an outdoor-based arboretum for biodiversity

Table 3. Preferences of long-tailed macaques forage

Pair-test	Habitat Paired	AVE	Std. Dev.	Lower Bound	Upper Bound	t-value	p-value
Pair 1	Captive 1–Captive 2	4.47733E1	41.799	0.908	88.638	2.624	0.047*
Pair 2	Captive 1–Tinjil	3.85083E1	44.988	-8.703	85.720	2.097	0.090
Pair 3	Captive 1–Wild	4.55800E1	63.514	-21.073	112.233	1.758	0.139
Pair 4	Captive 2–Tinjil	-6.265	23.801	-31.243	18.713	-0.645	0.547
Pair 5	Captive 2–Wild	0.807	26.684	-27.197	28.810	0.074	0.944
Pair 6	Tinjil–Wild	7.072	32.076	-26.590	40.733	0.540	0.612

*Note: p-value<0.05 (one-tailed)

Table 4. Result of t-test for in the artificial and natural habitats category for each frequency behaviours occur

Behaviour	t-value	p-value
Feeding	1.172	0.181
Locomotion	1.694	0.116
Sleeping	0.631	0.296
Grooming	1.688	0.117
Playing	-0.701	0.278
Agonistic	-2.576	0.062

*Note: p-value<0.05 (one-tailed)

conservation; it is maintained with a fruit garden, eco-edutourism, oil palm plantations, and a reservoir (Fachrozi and Setyawatiningsih 2020). All individuals show normal behaviours like another behaviour study of primates in the conservation area (Albani *et al.* 2020; Fitriyah *et al*. 2021) and kindly different activity behaviour between Captive 1 (outdoor-based) and Captive 2 (fully-housed). According to (Beisner and Isbell 2008), an outdoor captive factor affects the rhesus macaque's daily activities, namely the ground substrate condition. Captive 2 commonly shows stereotypical behaviour. Nevertheless, there were no significant differences in stereotypic behaviour between groups (Kruskal-Wallis test, p-value>0.05) (Indrarini 2015) because of the origin of LTP that former of dancing monkey. Indeed the condition of each individual in Captive 2 expresses less normal behaviour than the stereotypes. As we know before, dancing monkeys former would impact normal behaviour (Agoramoorthy and Hsu 2005; Takeshita, 2015; Nasution 2022) as well as potential to be the source of zoonosis that would impacted to human (Citraningputri *et al.* 2017). Besides, the primate's captive was reported to express abnormal behaviours (Garner 2005; Jacobson, Ross and Bloomsmith 2016; Lutz and Brown 2018; Mallapur and Choudhury 2003; Pomerantz, Paukner and Terkel 2012; Vandeleest, Mc Cowan and Capitanio 2011), because primate's behaviour in the captive always depended on the captive's environment and other external factors such as human-primate interaction and restricted space (Hosey 2005).

Furthermore, based on Table 3, other pairs such as Pair 2, Pair 3, Pair 4, Pair 5, and Pair 6 do not show significant behaviour (p-value>0.05). This whole pair means that they express all their behaviours with almost no difference, of course, between captive habitats with Tinjil and wild (there are naturally well) and Tinjil−wild, all almost similarly expressing their behaviour. Although the statistical results state that captive habitats have different levels of significance, the statistical results between them and natural habitats are the opposite. In this case, it is clear that environmental conditions mainly affect the limited captive environment (Birkett and Newton-Fisher 2011). Natural resources and wildly-like have a much better natural environment as evidenced by the resources that support their lives (Wich and Marshall 2016). In addition, the statistical results show that the state between artificial habitat and natural habitat shows a similar daily activity of LTM (Table 4, each behaviour does not show a significant difference, p-value>0.05). This can be possible even if they are in a captive environment, still trying to show the daily

activities they should do when they are in the wild. According to (Sajuthi *et al.* 2016), the behaviour of LTM is closely related to the way and in which they live. In addition, the cause of their behaviour is based on the stimulus obtained, internal or external, and in this study, six statistically compared behaviours are found to occur in all their research habitats (Table 4, all p-value>0.05). These six behaviours include innate behaviour (feeding, locomotion, sleeping) and learned behaviour (grooming, playing, agonistic) as examples of their daily behaviour that is often studied. In artificial and natural habitats, they can express all six behaviours well (although the frequency and duration are different due to the habitat conditions and influenced by stimulus types).

The proportion of individual numbers of each habitat also influences all behaviours. As well as LTM as social primates (Sajuthi *et al.* 2016; Supriatna and Wahyono 2000), it depends on the individuals' number or population size that influences their daily behaviour (Sajuthi *et al.* 2016). This study has the highest group size in the wild, followed by Captive 2. Based on the statistical result of Pair 5 (Captive 2–Wild), although the total individuals in this group of two habitats are the highest, they still show similar daily activity or behaviour (there is no significant difference). However, in Captive 2, the total number of individuals observed is splitted into four houses, which is not comparable with the total number of individuals in the wild, only in one considerable troop, although all the individuals on Captive 2 are statistically explained for their daily behaviour (Indrarini 2015).

Meanwhile, captive conditions made life longer for primates. However, a reversed sex bias in lifespan was observed between wild and captive populations (Hämäläinen *et al.* 2014). In the wild situation, various conditions of social structure may depend on age groups that can control the home range area and obtain unlimited resources; of course, the amount of sex present in the group affects their behaviour and the dominance and hierarchy (Hidayat *et al.* 2019; Langbein and Puppe 2004; Mishra *et al*. 2020b; Swindler 1998).

Other factors that explain the comparison between daily behaviour in the captive and wild include welfare enhancement, which depends on the behaviour variances, social factors, and environmental conditions (Howell and Cheyne 2019). In this study, all pairs (Table 3) between captive and wild (Tinjil also), except Pair 1, show the highest variance in the result of Pair 3, which means that Pair 3 has six behaviours with high fluctuating in the behaviour frequency compared to other pairs. Besides, Captive 1 and wild together influenced the human presence, so the factor of the human-primate interface also contributed to the behaviour's fluctuation.

Primates can adapt to the environment (Hadi *et al.* 2007; Hanya *et al.* 2020), even with anthropogenic disturbance or captive or zoo-liked. Studies by (Almeida-Rocha *et al.* 2017) supported the argument of primate responses to anthropogenic disturbance. Besides, (Hosey 2005) also reported that the zoo or captive environment made primates adapt to the limited environment more. Other wild-like situations, such as the forest, also reported that primates would adapt to the forest's edge changes (White *et al*. 2010). These would affect the behaviours and daily activity budget. Our study can determine an early welfare situation and nature-based environment for the captive-building and also for the basis to control the group or population size, which can be applied in the captive or wild conditions; then, in the future, this study can propose the conservation model with focus on their behaviours.

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