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STUDY OF THE EFFECTIVENESS OF ENVIRONMENTAL ENRICHMENT ON LONG-TAILED MONKEYS (*Macaca fascicularis*) WITH ABNORMAL BEHAVIOR

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ABSTRACT

The purpose of this study is to identify the efficiency of ecological enrichment in reducing abnormal behavior in Macaca fascicularis. Behavioral observations were conducted on four Macaca fascicularis that exhibited abnormal behavior, comprising three males and one female, using the focal animal sampling method. This method involved selecting one individual from the group and recording its behavior for a set period, then rotating to another individual. Behavioral observations began without enrichment; then, enrichment treatment was provided in the form of puzzle balls and feeding tubes containing carrots and long beans. Each observation was conducted over a period of 2 weeks, with an observation frequency of twice a day for 30 minutes. The study's findings indicated that the dominant behavior of Macaca fascicularis before enrichment was given showed abnormal behavior, including resting and agonistic behavior. Dominant behavior after enrichment, such as using a puzzle ball or feeding tube, included foraging, eating, and abnormal behavior. The effectiveness of both enrichments is proven by the repeated measures ANOVA test, which yields results (Sig. 0.007 < 0.05). This demonstrates a marked average distinction in reducing abnormal behavior in Macaca fascicularis.

INTRODUCTION

Long-tailed macaques (*Macaca fascicularis*) are forest-dwelling primates that play a crucial role in the natural ecosystem. In their natural habitat, these macaques are accustomed to living in groups. A single group of *Macaca fascicularis* consists of

multiple males and females, following a multimale-multifemale social structure (Husni et al., 2017). *The Convention on International Trade in Endangered Species of Wild Fauna and Flora* classifies *Macaca fascicularis* under Appendix II, meaning the species is at risk of extinction if trade continues excessively without proper regulation (CITES, 2021). The Ministry of Environment and Forestry (KLHK) has set a catch quota for long-tailed macaques, allowing a total of 2,000 to be captured (Sari, 2024). Based on this regulation, in 2016, CV Inquatex captured 200 individuals, which were used as breeding (KSDAE, 2018). Another institution engaged in captive breeding for conservation purposes is the PSSP (Nuraisah, 2015).

The Primate Animal Study Center (PSSP) is a beacon of hope in the field of primate conservation. This institutional organization is dedicated to primate conservation studies, and its work with *Macaca fascicularis* is particularly noteworthy. These primates are housed in both colony and individual cages at PSSP, where a key principle in ex-situ conservation is addressing daily behavioral challenges, particularly environmental limitations that restrict the expression of natural behaviors. A confined captive environment can present various challenges, especially concerning their welfare and behavior. One indicator of compromised welfare in captive *Macaca fascicularis* is the emergence of abnormal behaviors (Sajuthi et al., 2016).

Abnormal behavior refers to repetitive actions with no apparent purpose or function. Abnormal behavior can be recognized by the presence of unusual body postures or movements that are repeated over a prolonged period (Ai, 2015). Several factors contribute to the manifestation of abnormal behavior. These risk factors include several environmental conditions, such as nursery rearing, single housing, and clinical procedures (Gottlieb et al., 2015). Iskandar & Kyes (2016) also noted that abnormal behavior occurs when animals are kept in captivity for an extended period, are caged individually, have no visual or auditory contact with other animals, or are confined to small cages without environmental stimulation. The emergence of this abnormal behavior can be used as a sign or indicator that the animals in that environment are experiencing psychological distress (Haromaen, 2023). One strategy to address this issue is the implementation of an environmental enrichment program (Annisa, 2023).

Environmental enrichment is a crucial aspect of primate conservation that demands our attention. It is the process of providing an environment that encourages species-

typical behaviors, promotes behavioral choices, and enhances animal welfare (Annisa, 2023). The implementation of enrichment can determine how well individuals and populations adapt to various captive environments (Nasution et al., 2022). Research by Albanese et al. (2021) indicated that the level of abnormal behavior after being given environmental enrichment did not exceed 3% and was associated with reduced aggression. This promising result underscores the potential of environmental enrichment to improve the welfare of *Macaca fascicularis*. However, the effectiveness of environmental enrichment for *Macaca fascicularis* exhibiting abnormal behaviors at PSSP has not yet been reported. This is a gap in our understanding that urgently needs to be addressed. Therefore, research is needed to evaluate the suitability of enrichment facilities provided for *Macaca fascicularis* in research facilities, thereby improving their activity levels and natural behaviors.

MATERIALS AND METHODS

Observations were conducted at the Primate Animal Study Center (PSSP) from August to November 2024. The equipment used in this study included an ethogram sheet, writing tools, a data board, a stopwatch, personal protective equipment (PPE), and enrichment devices such as a puzzle ball and a feeding tube. The materials used consisted of four *Macaca fascicularis* individuals, carrots, and long beans. This study was conducted on four *Macaca fascicularis* individuals, comprising three males and one female, aged between 5 and 9 years, all of whom exhibited abnormal behaviors. The observation process began with a habituation phase to allow adaptation between the observers and the *Macaca fascicularis*. Observations were carried out under three conditions: (1) without enrichment, (2) with a puzzle ball, and (3) with a feeding tube. The enrichment devices were filled with carrots in the morning and long beans in the afternoon. Each observation lasted for two weeks, with a frequency of twice daily: in the morning from 08:00 to 09:00 WIB and from 1:00 to 2:30 p.m. WIB. The study employed the focal animal sampling method, a direct data collection technique where a single individual is observed as the primary subject. Data analysis was conducted using both quantitative and qualitative approaches. Quantitative analysis was performed using Microsoft Excel to determine the percentage of observed behaviors, which were then

presented in graphical form. Statistical analysis was conducted using the repeated measures test in IBM SPSS 26 to assess significant differences in abnormal behaviors. The formula used to calculate behavioral percentages is as follows:

$$\text{Behavior x} = \frac{Frequency\ of\ behavior\ x}{Total\ scan\ of\ all\ behavior} \text{ x } 100\%$$

Qualitative analysis involved describing the quantitative findings based on reference sources obtained through discussions and supported with relevant literature.

RESULTS AND DISCUSSION

Research on the effectiveness of environmental enrichment has primarily been found in group-housed macaques. This study, however, focused on individually housed macaques, which are often more prone to exhibiting abnormal behavior than those housed in groups. The use of the Repeated Measures ANOVA analysis method provides higher statistical power by controlling for inter-individual variation, thus enhancing the validity of the results. The research, conducted at the Primate Animal Study Center in Indonesia, is particularly relevant as it provides empirical data that can directly inform the development of local primate environmental enrichment standards.

Behavior is an action or series of actions that changes the relationship between an organism and its environment. Behavior can occur as a result of an external stimulus or as a reaction to external influences (Amrullah et al., 2021). Typical behavior in *Macaca fascicularis* includes social, agonistic, affiliative, sexual, play, and feeding behaviors (Iskandar & Kyes, 2016). Meanwhile, abnormal behavior is a type of behavior that occurs repeatedly without a clear purpose. Abnormal behavior occurs in *Macaca* kept in animal laboratories, especially *Macaca* kept individually (Palanco et al., 2021). Sinta et al. (2022) stated that repetitive movements, such as spinning and jumping, often characterize abnormal behavior in Macaca in captivity. Other abnormal behaviors, according to Fitria's (2020) research, include somersaults, shaking the body, and hair pulling.

Macaca fascicularis Behavior without Environmental Enrichment

The research findings on Macaca fascicularis without environmental enrichment suggest the need for further investigation. They reveal that treatments without

environmental enrichment resulted in dominant abnormal behavior, with percentages of 40% (M1), 42% (M2), 46% (M3), and 58% (M4). The second dominant behavior was resting, with the percentages 12% (M1), 27% (M2), 21% (M3), and 19% (M4). The third dominant behavior, namely rest behavior, had percentages of 20% (M1), 9% (M2), 14% (M3), and 12% (M4). These results are presented in Figure *1, highlighting* the need for further research in this area.

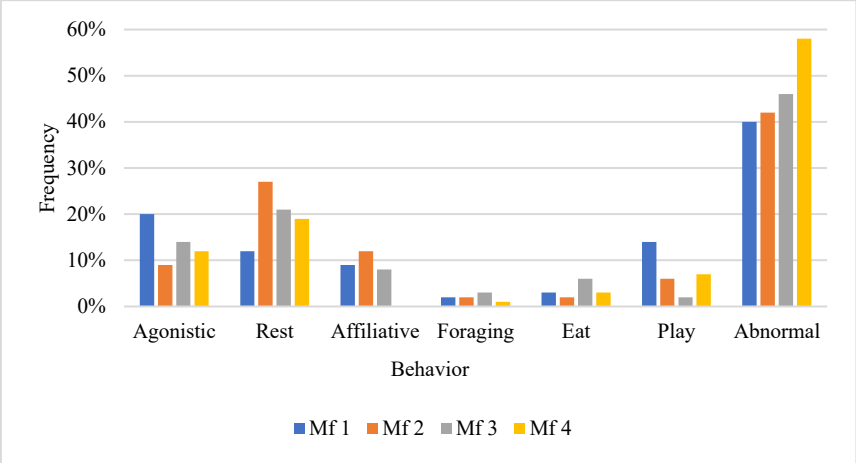

Figure 1. Percentage diagram of *Macaca fascicularis* behavior without enrichment

The abnormal behaviors observed in each *Macaca fascicularis* individual varied and included pacing, repetitive jumping, somersaulting, body shaking, hair pulling, and self-biting. These high levels of abnormal behavior, often indicative of anxiety or discomfort, are likely due to the individual caging of the *Macaca fascicularis*, which induces stress. The observed dominant abnormal behaviors in each individual are a distressing sign of the discomfort experienced by the *Macaca fascicularis* at the PSSP. This stress is likely exacerbated by noise from activities such as cage sanitation and external sounds. The lack of environmental enrichment also deprives them of natural behaviors such as foraging and play. This observation aligns with findings reported by Polanco et al. (2021), who noted that laboratory Macaca often exhibit abnormal behaviors rarely observed in the wild, particularly in individually caged individuals. Furthermore, Iskandar & Kyes (2016) suggest that *Macaca fascicularis* kept individually for a long time shows an increase in abnormal behavior.

Resting behavior, the second most dominant activity observed in *Macaca fascicularis*, plays a crucial role in their recovery. This behavior, consisting of sitting, observing the environment, and lying down within the cage, is a non-social activity that serves as a restorative mechanism for the *Macaca fascicularis* after performing abnormal

behavior. Resting behavior is essential for individuals following activities like eating, playing, and vocalizing (Ramadhan et al., 2022). In this study, the *Macaca fascicularis* experienced conditions such as limited social interaction, restricted movement, and minimal environmental stimulation, which likely contributed to the increased duration of resting behavior. Emphasizing the role of resting behavior in recovery can help the audience understand the importance of providing a conducive environment for these animals.

Agonistic behavior, the third most dominant, is characterized by actions related to aggression or conflict. This behavior commonly occurs in contexts of competition for dominance, territory, or access to resources such as food or mates (Fortman et al., 2018). The observed agonistic behaviors in *Macaca fascicularis* at the PSSP include open mouth, staring, cage shaking, and threatening. This is in accordance with the statement of Iskandar & Kyes (2016), who reported similar agonistic behaviors, such as open mouth, stare, cage shaking, and threatening, in captive *Macaca fascicularis*. *However, it's* important to note that these behaviors can also be a response to perceived threats, such as the close approach of humans or a perceived threat to their food. This observation aligns with Stéphanie et al. (2019), who reported that *Macaca fascicularis* exhibit fang display, vocalizations, and vigilant observation of humans, predators, or other groups in response to perceived threats. Underlining the impact of environmental factors on agonistic behaviors can make the audience feel the need for better management and care for these animals.

Macaca fascicularis Behavior with Puzzle Ball Feeding

Our behavioral observations of four *Macaca fascicularis* with puzzle ball enrichment have revealed clear patterns. Foraging emerges as the dominant behavior, with percentages of 34% (M1), 42% (M2), 43% (M3), and 40% (M4). The second dominant behavior, eating, accounts for percentages of 28% (M1), 30% (M2), 32% (M3), and 30% (M4). The third dominant behavior, abnormal behavior, is also noted, with a percentage of 16% (M1), 17% (M2), 14% (M3), and 12% (M4). These findings, presented in Figure 2, provide a clear visual representation of the data, making it *easier for* you to understand and interpret.

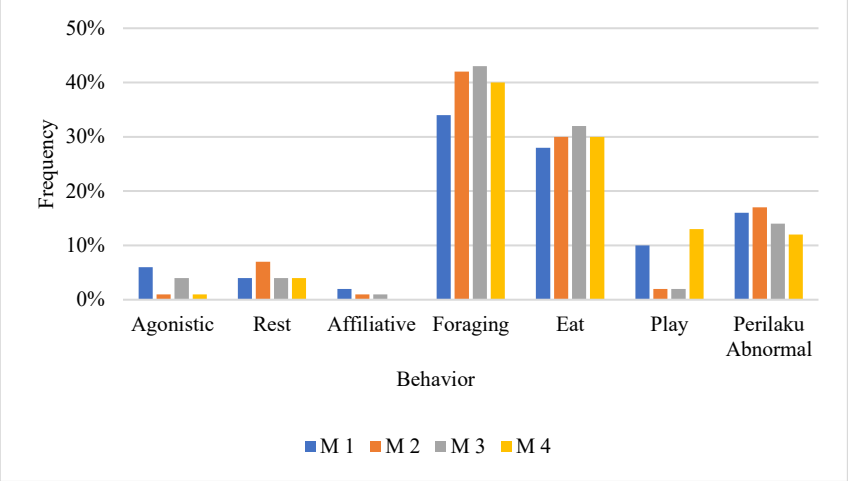

Figure 2. Percentage diagram showing *Macaca fascicularis* behavior during the provision of puzzle balls

Foraging, the act of searching for food within an animal's home range (Sumarto & Koneri, 2016), is a behavior that *Macaca fascicularis* at PSSP excel in, thanks to the puzzle ball. This enrichment tool, designed to provide a cognitive challenge, stimulates the brain of these primates to think and find ways to obtain food. The presence of carrots and long beans within the puzzle ball serves as a strong motivator for *Macaca fascicularis*, leading to intensified foraging behavior. The animals' ability to manually manipulate the puzzle ball, inserting their hands into the small apertures, is a testament to their intelligence. The foraging behavior varied across the observed *Macaca fascicularis* individuals, each demonstrating their unique problem-solving skills. Nash et al. (2021) found that puzzle ball enrichment provided in captivity can increase the chances of foraging for food that can only be obtained by manipulating these objects in specific ways, such as inserting hands, shaking, and rotating the device.

The second most frequent behavior observed is feeding. This activity, which involves searching for food, selecting it, placing it into the mouth, chewing, and swallowing, was observed in the Macaca fascicularis. The animals consumed carrots and long beans provided inside the puzzle ball. *Notably, Macaca fascicularis* showed a preference for carrots over long beans, a choice that can be attributed to their preference for sweet flavors, as stated by Astuti (2016). The sweeter taste of carrots was more appealing to the *animals than* the slightly bitter taste of long beans.

The third most frequently observed behavior during the provision of the puzzle ball was abnormal. This behavior, which occurred in response to external stimuli, was notably

reduced with the introduction of the puzzle ball. While abnormal behavior did not disappear completely, its frequency was significantly minimized. This finding is consistent with the study by Howard & Freeman (2022), which stated that enrichment provided to primates can reduce abnormal behavior, although it does not eliminate it. According to Rajuli (2024), enrichment measures such as providing puzzle balls, adding toys, or rotating objects within the enclosure have been proven to help decrease the frequency of abnormal behavior. However, such behavior persists in some cases. This is because artificial environments, even when enriched, cannot fully replicate the complex natural conditions of their native habitat (Coleman & Novak, 2017).

Macaca fascicularis Behavior with Feeding Tube Provision

The results of our meticulous observations on the behavior of four *Macaca fascicularis* that received tube feeding treatment showed a clear dominance in foraging and eating behavior. The frequency of foraging behavior was 43% (M1), 45% (M2), 45% (M3), and 43% (M4). Feeding behavior was observed at 36% (M1), 40% (M2), 35% (M3), and 36% (M4). The percentage of behaviors is shown in Figure 3, a testament to the thoroughness of our research process.

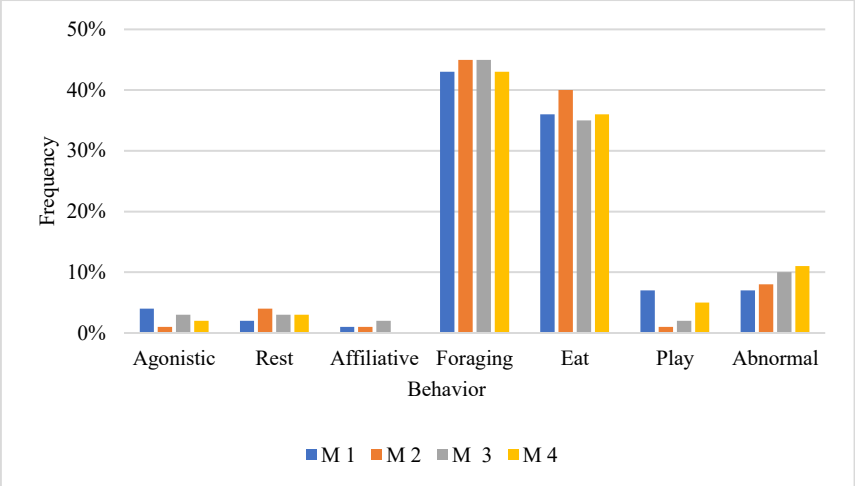

Figure 3. Diagram showing the Behavior Percentage of *Macaca fascicularis* with Feeding Tube Provision.

The observed Macaca fascicularis showed a high level of foraging behavior, primarily due to their strong interest in the feeding tube enrichment. The use of carrots and long beans as a reward for manipulating the object was a key motivator. M1, M2, and M3 demonstrated foraging by inserting both hands through the small holes in the device, as well as by rotating and shaking it to obtain food. *Macaca fascicularis* M4, on the other

hand, used only one hand to shake and rotate the feeding tube until the food was retrieved. This finding aligns with Nash et al.'s (2021) statement, suggesting that food-based enrichment, such as the feeding tube, can effectively motivate and increase the likelihood of foraging, requiring individuals to manipulate objects in specific ways.

Feeding behavior was the second most dominant behavior observed in *Macaca fascicularis* when a feeding tube was used. The observed individuals consumed carrots and long beans inside the feeding tube. When successfully retrieving a carrot, they would immediately place it in their mouth and chew it. However, when obtaining a long bean, they would first peel it to extract the beans before consuming and chewing them. This manipulation, facilitated by the feeding tube, significantly extended the feeding duration, a finding that is in line with Haslam's (2018) statement that manipulating food represents a fundamental part of the range of behaviors exhibited by most wild primates.

The Effectiveness of Puzzle Ball and Feeding Tube on Abnormal Behavior of Macaca fascicularis

Repeated measures ANOVA is a statistical method used when the same subject is measured multiple times under different conditions. This test aims to identify whether there is a significant difference in repeatedly measured data pairs (Fauziyah, 2020). Repeated measures testing is based on the assumption that the data must be normally distributed and homogeneous, although this is not absolute (Sari & Harjono, 2024).

Repeated Measures ANOVA

According to (Raharjo, 2019), if the p-value in a repeated measures ANOVA exceeds 0,05, the null hypothesis (H_0) is retained, and the alternative hypothesis (H_a) is rejected. The results of the repeated ANOVA test show a p-value of $0.007 < 0.05$; therefore, H0 is rejected and H1 is accepted. This indicates a significant difference in the abnormal behavior of *Macaca fascicularis* after being provided with enrichment in the form of puzzle balls and feeding tubes. These findings have practical implications for the design of enrichment strategies in primate care. The results of the repeated measures test are presented in Table 1.

Table 1 Outomes of the ANOVA Retest

Source		Mean square	P-value
Observation	*Sphericity assumed*	83934,750	0,007

Post-Hoc Test

The post hoc testing is conducted to examine multiple comparisons among treatment groups after the ANOVA. The findings, which reveal a notable difference (Sari & Harjono, 2024), are of significant importance. This test aims to identify which pairs of groups have significant differences. One of the commonly used methods is the Tukey test (Angriyani et al., 2021). The post hoc test findings are displayed in Table 2.

Table 2 Outcomes of post-hoc test

Observation	Mean±SD
P1	464,50±131,58
P2	237,25±51,62*
P3	195,25±25,83*

Note: P1 observation without enrichment, P2 observation with puzzle ball treatment, P3 observation with feeding tube action. Superskip indicates a significant difference ($p<0.05$)

Table 2 shows that observations without enrichment have an average value of 464.50 ± 131.58. This means that there is no significant difference in the average, indicating that the absence of enrichment does not lead to a significant change in behavior. Observations with puzzle balls have an average value of 237.25 ± 51.62, and observations with food tubes have an average value of 195.25 ± 25.83. This means that there is a significant average value in both enrichments, suggesting that these enrichment methods have a noticeable impact on the behavior of Macaca fascicularis.

The frequency of abnormal behavior before and after the enrichment treatments with a puzzle ball and feeding tube showed a significant difference. This is because the puzzle ball and feeding tube, as food-based enrichment devices designed with small holes, promote natural foraging behavior. This process offers essential mental stimulation, redirecting their focus away from abnormal behavior (Cannon et al., 2016).

These two enrichment methods play a crucial role in reducing the occurrence of abnormal behaviors. The puzzle ball and feeding tube encourage *Macaca fascicularis* to move and interact with their environment, helping to redirect their energy from abnormal behaviors to more productive activities. This increased physical activity helps keep *Macaca fascicularis* physically active and reduces aggressive behaviors often observed in animals that lack sufficient stimulation. Rianti et al. (2024) stated that enrichment can successfully promote species-specific natural behaviors, reduce the frequency of

abnormal behaviors, and improve the well-being of animals under human care. A well-designed enrichment program should consider the natural history and ecological characteristics of the species (Albanese et al., 2021). *Macaca fascicularis*, which is spread across Southeast Asia. Inhabits social groups composed of multiple males and females. One form of enrichment that can be used is food-based enrichment, such as the puzzle ball and feeding tube (Cannon et al., 2016). This enrichment strategy proves effective in situations where animals cannot be housed in social groups, as it helps reduce the occurrence of abnormal behaviors (Wooddell et al., 2019).

CONCLUSION

The dominant behaviors of *Macaca fascicularis* before the provision of enrichment included abnormal behavior, resting, and agonistic behavior. After the enrichment treatments with a puzzle ball or feeding tube, the dominant behaviors observed were foraging, feeding, and abnormal behavior. Abnormal behavior persisted because enrichment can only minimize it rather than eliminate it. However, the effectiveness of both enrichment methods was clearly demonstrated through a repeated measures ANOVA test, which showed a significant decrease in the average frequency of abnormal behavior, providing reassurance and confidence in the study's findings.

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