

# Pilot Study on Food-processing Behaviour by Males Long-tailed Macaques on Tinjil Island, Indonesia

Lola N. Hanifa<sup>1</sup>, Haikal I. Maulahila<sup>1</sup>, Anggitha Tambunan<sup>1</sup>, Dheana P. Dewi<sup>1</sup>, Dyah Perwitasari-Farajallah<sup>1,2</sup>, Puji Rianti<sup>1,2\*</sup>

<sup>1</sup>Study Program of Animal Biosciences, Department of Biology, Faculty of Mathematics and Natural Sciences, IPB University, Indonesia

<sup>2</sup>Primate Research Center, Institute of Research and Community Services, IPB University, Indonesia

## Abstract

Non-Human Primates (NHP) have a slow life history compared to other mammals due to their complex brain growth. Brain complexity correlates with behaviour complexity, especially feeding behaviour, which enables primates to have the capability in the leaf processing step, tool use, or even food washing. *Macaca fascicularis* on Tinjil Island is one of the NHP species conducting food-cleaning behaviour. Thus, this study aims to figure out the food-cleaning behaviour differences across the age classes of juvenile and male long-tailed macaques (LTM). The feeding behaviour of two age classes of male LTM through 3 different types of food processing was analysed using focal animal sampling and instantaneous recording methods. Then, the data were statistically analysed using Mann-Whitney and Kruskal-Wallis. We found that the frequency of using Step 0 and Step 1 of the food processing type was almost the same regardless of age class differences. Analysis within each age class showed different results that juvenile male LTM had a higher frequency of Step 0 and lower frequency of Step 1 than adult male LTM and vice versa. The result indicates no significant differences in the three food type processing between juvenile and adult male LTM.

**Key words:** brain-cognition, cynomolgus macaques, feeding-behaviour, juveniles, Tinjil

## 1. Introduction

Non-Human Primates (NHP) have a slow life history compared to other mammals (Harvey and Clutton-Brock 1985; Read and Harvey 1989; Jones 2011). Several theories have been suggested to answer the phenomena, but most likely are explained by brain size (Roos and Jones 2004; Barton and Capellini 2011). There is a positive correlation between brain size and the longevity of maturation age, where the larger brain species have a relatively long development than the small brain (Leigh 2004). Three models have been proposed to explain it. First, the large brain might result from the selection constraining high energy for brain development. So, it suppresses the energy for the body to grow fast. Secondly, they delay maturation to decrease the juvenile risk against conspecific competition and predators and then invest the energy in the brain. Third, the NHP invests its energy in optimizing brain size and delayed maturation age to provide enough time for the juvenile to learn complex social and

ecological problems (Roos and Jones 2004; Shultz and Dunbar 2007).

Based on these models, food is critical in influencing brain development (Roos and Jones 2004). The more food sustenance found, the greater risk received, and the less energy obtained will be less for development. Therefore, it makes sense for NHP to learn foraging skills for efficient feeding and survival (Roos and Jones 2004).

The complex behaviour, whether using tools or not, is indeed common in great apes. The current study of foraging skills in great apes reveals their capability in the leaf processing step, tool use, and food washing in chimpanzees, gorillas, and orangutans (Corp and Byrne 2002; Alltrix *et al.* 2013; Schupli *et al.* 2016; Neufuss *et al.* 2019). However, some studies have successfully reported this in monkeys, especially in food-cleaning behaviour. The most familiar study is *Macaca fuscata* on Koshima Island, which washed their food in the water (Hirata *et al.* 2008). The *Macaca fascicularis*, Vervet monkey, and Capuchin monkeys remove the sand from the food (Chiang

\*Corresponding author

Email Address : [pujirianti@apps.ipb.ac.id](mailto:pujirianti@apps.ipb.ac.id)

1967; Visalbreghi and Fragaszy 1990; Van de Wall *et al.* 2014). Interestingly, the food-cleaning behaviour may also appear in the long-tailed macaque (LTM) on Tinjil Island. The officer reported some picking the corn and rubbing their hands to clean it from the sand. So, in this study, we observed the males from two groups that habituated around the base camp. We also tried to shed light on the behaviour and whether it differs across the age classes. This study can be used as baseline information for further behavioural study, especially in food-cleaning behaviour conducted on Tinjil Island.

## 2. Materials and Methods

This pilot study was conducted on Tinjil Island, Banten, on October 2022. The objects of this study were male long-tailed macaques from two groups consisting of six adults and six juveniles (Table 1). Scars, hair colour, body size, and face identified every group member.

We observed the feeding behaviour of male

Groups	Individu	Age Class
Bule	Bule	Adult
	DMS	Adult
	VLN	Adult
	FTN	Juvenile
	LNH	Juvenile
	DPD	Juvenile
Jambul	Jambul	Adult
	SMN	Adult
	HKL	Adult
	TBN	Juvenile
	MJD	Juvenile
	TRB	Juvenile

Table 2. Ethogram feeding behaviour (food processing steps)

No.	Food processing steps	Food item
0	Pick	Corn
1	Pick, and remove sand around the food	Corn
2	Pick, remove sand around the food, peel	Banana

long-tailed macaques, which was separated into three food processing (Table 2) observed, using focal animal sampling (Altmann 1974) with a one-minute interval recording time. The observation started at 7:00 a.m. and stopped when objects were entirely moved out of sight. The total research observation hours were 18 hours. All data were transferred to Excel sheets to calculate the mean, and all statistical analyses were computed using the R version 4.2.0 software. Mann-Whitney and Kruskal-Wallis were used to statistically compare the frequency of each food processing between the two age classes.

## 3. Results

The male LTM from both groups has dominantly used food processing step 1 in the feeding behaviour, while step 2 is less used in this observation (Figure 1a). There is no significant difference between step 0 and step 1. Nevertheless, steps 0 and 1 differ statistically from step 2 (Table 2).

Each age class shows its dominant food processing step in feeding behaviour (Figures 1a and 1b), although the difference is not significant ( $P \geq 0.05$ ) (Table 3). Food processing step 0 is dominant in juvenile individuals, and step 1 is dominant in adults. Meanwhile, processing step 2 has a low frequency in both age classes (Figure 1b and 1c). However, if comparing the food processing within the age class, there is a significant difference ( $P \leq 0.05$ ) between step 2 and the other steps (Table 2). The adult and juvenile male individuals more frequently performed food processing steps 0 and 1 than step 2 (11%, 6%, 1%, 8.33%, 6.91%, and 1.43%, respectively) (Figure 1b and 1c).

## 4. Discussion

Statistically, it was found that the adults and juveniles LTM from Tinjil Island dominantly cleaned the corn first before entering it into their mouths. It might be a behaviour performed by the LTM population in Tinjil to clean their food. This similar behaviour was observed on vervet monkeys by rubbing grapes on a substrate and Japanese macaque by washing potatoes (Fiore *et al.* 2020; Van de Waal *et al.* 2014). However, it turned out that there are differences in the dominance of food type processing for each group.

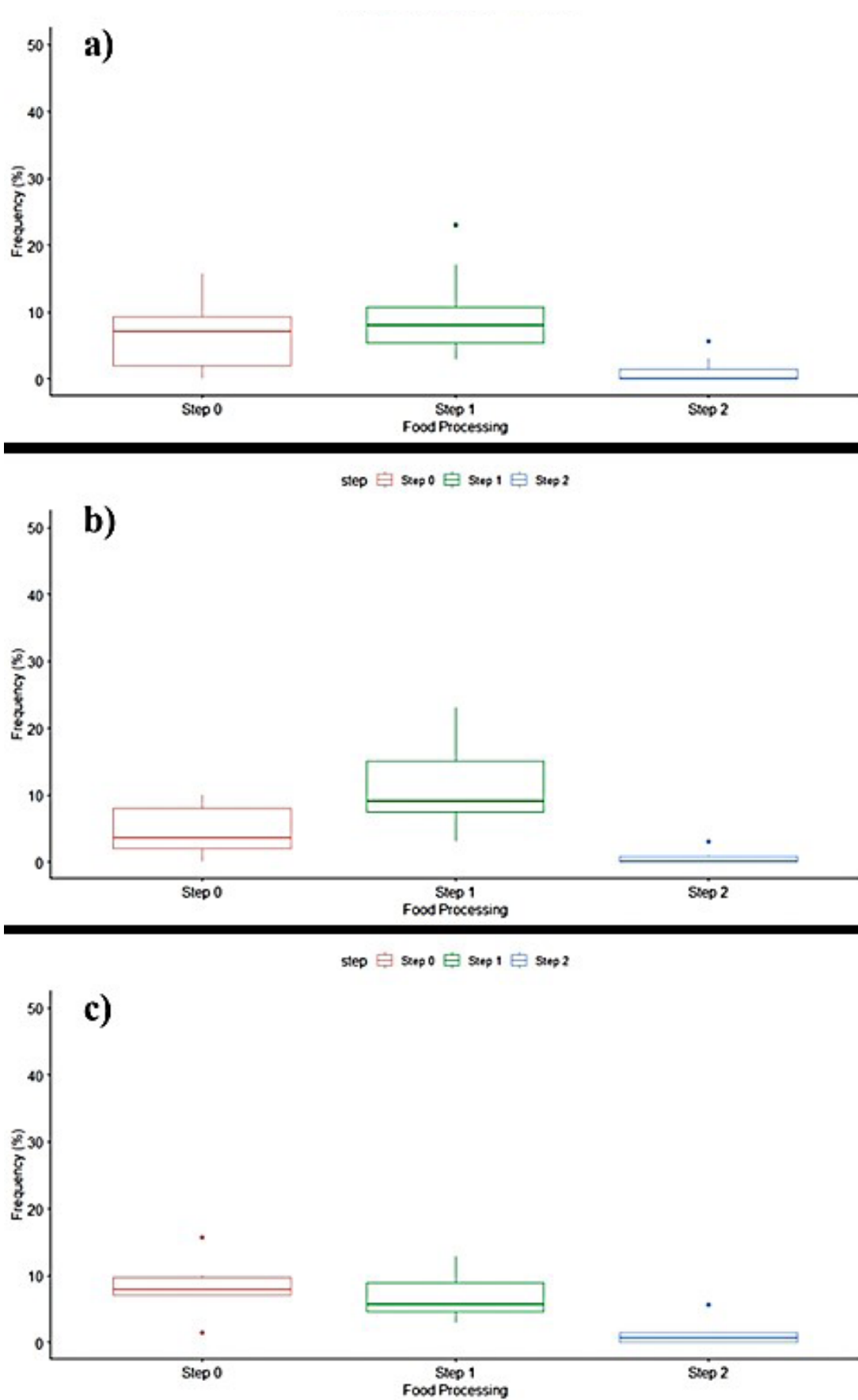


Figure 1. Food processing step on (a) all male LTM, (b) adult, and (c) juvenile individuals in Tinjil Island. The box is the frequency of food processing steps 0 (red), 1 (green), and 2 (blue).

Table 3. The significant level of food processing step on male LTM in Tinjil

Paired Age Class	P-value
<i>All age class</i>	
Step 0 vs Step 1	0.3396
Step 0 vs Step 2	0.0017*
Step 1 vs Step 2	0.0003*
<i>Between the age class (Adult vs Juvenile)</i>	
Step 0	0.3341
Step 1	0.2963
Step 2	0.5211
<i>Within the age class (step 0 vs step 1 vs step 2)</i>	
Adult	0.0074*
Juvenile	0.0119*

(\*) significant difference: p-value <0.05

Juvenile male LTM was mostly found to eat the corn directly without cleaning it first. Conversely, adult male LTMs were found to clean and eat the corn. The food item was kept between the two palms, and the adult male LTM moved the hands repeatedly in opposing directions, thus rubbing the food item before ingesting it. The difference in the frequency of food processing between adults and juveniles was likely caused by the adult male, which had more access to the available food. The narrow area of food spread by the officer led to more contact between adults and juvenile macaques that possibly created aggressive behaviour among the macaques. For example, adult male macaques would likely scold the juveniles if they tried to take the corn. This propelled the juvenile male macaques to eat the most accessible corn immediately without trying to clean it first.

Collecting food quickly without cleaning it first could become one of the feeding tactics of male juveniles LTM to optimize time in the feeding area (Pelaez *et al.* 2000). The findings of this study are also quite the same as those of Pal *et al.* (2017) found that from a total of 45 food rubbing events with LTM

hands were observed; the adult males, subadult males, adult females, and juveniles performed 7, 16, 19, and 3 times, respectively. Another study by Kendal *et al.* (2005) found that adult callitrichids monkeys were discovered to be more innovative and more often succeed at tasks given than nonadults. Adult macaques are superior because they have larger brain sizes than juvenile macaques. This might imply that adults exhibit more complicated food processing than juveniles. On top of that, this can also be linked to the brain size of both age classes because food processing and cognitive complexity have connections with brain size (Neufuss *et al.* 2019).

Both age classes have a low frequency of eating bananas because the bananas given were still unripe. According to Huang *et al.* (2021), macaques prefer to eat ripe fruit because of its sweet flavour and rich mouthfeel. However, in this study, juvenile macaques had a higher frequency of eating bananas than adults. Juveniles' tendency to eat unripe bananas might be due to adults' control of corn, which caused low corn availability for juveniles. Furthermore, less frequency of step 2 in adult male LTM could also be the impact of higher consumption of spread corn.

Results indicated no significant differences in the three food type processing between juvenile and adult male LTM. This was probably caused by the small sample size used in this study, which made us still need to discover the full complexity and variety of the food processing technique used by long-tailed macaques on Tinjil Island. The collection and processing of another food could be studied in greater detail to determine if macaques show hierarchically structured sequences of behaviour (Tan *et al.* 2016).

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## References

- Alltriz M, C Tennie, & J Call. 2013. Food washing and placer mining in captive great apes. *Primates*. 54: 361-370, 10.1007/s10329-013-0355-5
- Altmann, J. 1974. Observational sampling methods. *Animal Behaviour*. 49 (3): 227–266.
- Barton RA and I Capellini. 2011. Maternal investment, life histories, and the cost of brain growth in mammals. *Proceedings of the National Academy of Sciences*, 108(15): 6169-6174, <https://doi.org/10.1073/pnas.1019140108>
- Chiang M. 1967. Use of tools by wild macaque monkeys in singapore. *Nature*. 214: 1258-1259, <https://doi.org/10.1038/2141258a0>
- Corp N & RW Byrne. 2002. Leaf processing by wild chimpanzees: Physically defended leaves reveal complex manual skills. *Ethology*. 108: 673-696. ISSN: 0179–1613
- Fiore, A. M., Cronin, K. A., Ross, S. R., & Hopper, L. M. (2020). Food Cleaning by Japanese Macaques: Innate, Innovative or Cultural? *Folia Primatologica*, 91(4), 433–444. <https://doi.org/10.1159/000506127>
- Harvey PH & TH Clutton-Brock. 1985. Life history variation in primates. *Evolution*. 39(3): 559-581, <https://doi.org/10.1111/j.1558-5646.1985.tb00395.x>
- Hirata S, K Watanabe, and M Kawai. 2008. “Sweet-potato washing” revisited. In Matsuzawa T (Eds), *Primate Origins of Human Cognition and Behavior*. Tokyo: Springer. [https://doi.org/10.1007/978-4-431-09423-4\\_24](https://doi.org/10.1007/978-4-431-09423-4_24)
- Huang, F. Y., Sutcliffe, M. P. F., & Grabenhorst, F. (2021). Preferences for nutrients and sensory food qualities identify biological sources of economic values in monkeys. *Proceedings of the National Academy of Sciences of the United States of America*, 118(26), 18–25. <https://doi.org/10.1073/pnas.2101954118>
- Jones JH. 2011. Primates and the evolution of long, slow life history. *Current Biology*. 21. 10.1016/j.cub.2011.08.025
- Kendal RL, Coe RL, & Laland KN. 2005. Age differences in neophilia, exploration, and innovation in family groups of callitrichid monkeys. *American Journal of Primatology*. 66(2): 167–188.10.1002/ajp.20136
- Leigh SR. 2004. Brain growth, life history, and cognition in primate and human evolution. *American Journal of Primatology*. 62: 139-164. Doi: 10.1002/ajp.20012
- Neufuss, J., Robbins, M. M., Baeumer, J., Humle, T., & Kivell, T. L. (2019). Manual skills for food processing by mountain gorillas (*gorilla beringe beringe*) in bwindi impenetrable national park, Uganda. *Biological Journal of the Linnean Society*, 127(3), 543–562. <https://doi.org/10.1093/biolinnean/bly071>
- Pal A, Kumara HN, Mishra PS, Velankar AD, & Singh M. 2017. Extractive foraging and tool-aided behaviours in the wild Nicobar long-tailed macaque (*Macaca fascicularis umbrosus*). *Primates*. 59(2), 173–183, 10.1007/s10329-017-0635-6
- Pelaez F, Gil-Burmann C, & Sanchez S. 2000. Feeding tactics in juvenile rhesus monkeys (*Macaca mulatta*). *American Journal of Primatology*. 51(2): 147–152, 10.1002/(sici)1098-2345(200006)51:2<147::aid-ajp4>3.0.co;2-1
- Read AF and PH Harvey. 1989. Life history among the eutherian radiation. *The Zoological Society of London*. 219: 329-353, <https://doi.org/10.1111/j.1469-7998.1989.tb02584.x>
- Roos C & KE Jones. 2004. Socioecology and the evolution of primate reproductive rates. In PC Lee (Eds), *Comparative primate socioecology* (PP 73-105). UK: Cambridge University Press.
- Schuppli C, SIF Forss, EJM Meulman, N Zweifel, KC Lee, E Rukmana, ER Vogel, MA van Noordwijk, and CP van Schaik. 2016. Development of foraging skills in two orangutan populations: needing to learn or needing to grow?. *Frontiers in Zoology*. 13(43), 10.1186/s12983-016-0178-5
- Shultz S & RIM Dunbar. 2007. The evolution of the social brain: anthropoid primates contrast with other vertebrates. *Proceeding of The Royal Society B*. 274: 2429-2436, 10.1098/rspb.2007.0693



- Tan, A. W. Y., Luncz, L., Haslam, M., Malaivijitnond, S., & Gumert, M. D. (2016). Complex processing of prickly pear cactus (*Opuntia sp.*) by free-ranging long-tailed macaques: Preliminary analysis for hierarchical organisation. *Primates*, 57(2), 141–147, <https://doi.org/10.1007/s10329-016-0525-3>
- Van de Waal, E., Bshary, R., & Whiten, A. (2014). Wild vervet monkey infants acquire the food-processing variants of their mothers. *Animal behaviour*, 90, 41–45, <https://doi.org/10.1016/j.anbehav.2014.01.015>
- Visalberghi E & DM Fragaszy. 1990. Food-washing behaviour in tufted capuchin monkeys, *cebus apella*, and crab eating macaques, *Macaca fascicularis*. *Animal behaviour*. 40(5): 829-836, [https://doi.org/10.1016/S0003-3472\(05\)80983-2](https://doi.org/10.1016/S0003-3472(05)80983-2)