

Stereotype and abnormal behaviour in *Macaca fascicularis* captive: Towards good environmental enrichment for its sustainability

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Abstract. *Stereotypes and abnormal behaviour (SAB) exhibited by long-tailed macaques (LTMs) have attracted the attention of behavioural study, although caused by many factors. Mostly found in captivity, it can also occur in the natural environment. This study aims to review several scientific articles on SAB in LTMs, as well as for environmental enrichment conditions. This study used a web-based survey to collect all scientific publications related to SAB in LTMs with a statistical correlation test to determine the cost of individuals' needs as an animal model for the research and the regression test to determine the effects of the number of individuals observed, as well as SAB types in LTMs. This study used two variables: the number of individuals and SAB types and sorted by rank. The statistical correlation result shows that the cost of individuals' needs as an animal model for the research and publication's year is positive correlate. The regression test result shows that the total number of individuals observed is significantly different (p -value <0.05 , one-tailed) between SAB types. The primary goal of stimulating environmental enrichment is to give pleasant options for animals based on the treatment object in the study supplied while emphasising animal welfare and promoting research effectiveness.*

Keywords: *captivity, cynomolgus macaque, endangered primate, long-tailed macaque, unusual behaviour.*

Abstrak. Stereotip dan perilaku abnormal (SPA) pada monyet ekor panjang (MEP) telah menarik perhatian dalam studi tingkah laku, hal ini disebabkan oleh banyak faktor. Sebagian besar kondisi ini dijumpai di penangkaran, namun dapat pula terjadi di alam. Penelitian ini bertujuan untuk mengkaji beberapa artikel ilmiah tentang SPA pada spesies MEP, serta untuk kondisi pengayaan lingkungannya. Penelitian ini menggunakan survei berbasis web untuk mengumpulkan semua publikasi ilmiah dengan uji korelasi statistik untuk mengetahui jumlah individu digunakan untuk hewan model penelitian dan uji regresi untuk menganalisis pengaruh jumlah individu dalam riset, jenis SPA yang terjadi. Penelitian ini menggunakan dua variabel: jumlah individu dan jenis SPA lalu diurutkan

berdasarkan peringkat. Hasil korelasi statistik menunjukkan bahwa jumlah individu hewan model dengan tahun publikasi berkorelasi positif. Hasil uji regresi menunjukkan bahwa jumlah total individu yang diamati dalam riset berbeda nyata (nilai- $p < 0,05$, satu-arah) terhadap jenis SPA. Tujuan utama pengayaan lingkungan adalah untuk memberikan pilihan yang menyenangkan bagi hewan berdasarkan objek perawatannya dalam penelitian, serta menekankan kesejahteraan hewan dan mendukung efektivitas penelitian.

Kata kunci: monyet ekor panjang, monyet cynomolgus, primata terancam, penangkaran, tingkah laku abnormal.

INTRODUCTION

The abnormal behaviour was commonly known as a stereotype, which was first reported to disappear in primates in 1966 for abnormal movement in marmosets (Berkson et al., 1966). Besides, in 1977, at least four of seven primate families were also reported to express the stereotype behaviour in captive conditions (Trollope, 1977), as well as in rhesus macaques in the fully-housed cage (Paulk et al., 1977). As we know, if the animal was phenotypic for the abnormal behaviour, it can be related to its welfare condition (Mason & Rushen, 2006) as well as the scientific outcomes of the experimental research (Garner, 2005).

Many factors influence animals to be stereotyped and have abnormal behaviour. Commonly known as environmental enrichment (Kerridge, 2005) or captive condition (Mallapur & Choudhury, 2003), as well as in the zoo-living condition, also probable to have some stereotyped behaviour (Birkett & Newton-Fisher, 2011; Hosey, 2005; Jacobson et al., 2016). Besides, one of the primates' taxa was reported for stereotyped and abnormal behaviour, such as macaques (Koyama et al., 2019; Paulk et al., 1977; Vandeleest et al., 2011). The macaque was evenly used in laboratory experiments (Abee et al., 2012) that correlated with a captive or restricted living area condition (Sajuthi et al., 2016), so for this reason, the chance to have some stereotyped and abnormal behaviour is also possible. In addition, the macaque was also used as the dancing monkey in Indonesia (called *Topeng Monyet*), the former reporting stereotyped and abnormal behaviour (Ai, 2015). Today, the current IUCN status for one macaque widely distributed species, the long-tailed macaque (*Macaca fascicularis*), is endangered, with the details as "*Long-tailed Macaque Macaca fascicularis has most recently been assessed for The IUCN Red List of Threatened Species in 2022. Macaca fascicularis is listed as Endangered under criteria A3cd*" (Hansen et al., 2022).

Related scientific publications about the stereotype and abnormal behaviour in a long-tailed macaque are limited, but it is not to be sure that this species would not even be researched. No one else in the review paper related to this species' stereotyped and abnormal behaviour. In addition, it is an important thing that would be affected in the context of animal welfare, as well as sustainability captive. So, this paper tried to review the scientific publications related to the stereotype and abnormal behaviour of the endangered macaque, the long-tailed macaque, as well as in the context to support their sustainability in captivity life.

MATERIAL AND METHOD

Survey Technique

This research used a mini-review method that refers to the previous study scheme (Al Hakim et al., 2021; Al Hakim, Nasution, & Rukayah, 2022) with modifications to support the statistical analysis, as well as conducted from a web-based survey from a related study (Al Hakim, Imtiyaz, et al., 2022). The method schematic includes literature study, title selection, abstract screening, full-text reading, and mini-review. The inclusive criteria for literature study include all scientific articles, Indonesian or English language, academic publications (thesis or dissertation), and unlimited years of publication. The exclusion criteria include unpublished works, the kind of indexed databases, other species and subspecies from *Macaca fascicularis*, and living habitats. Keywords used Boolean rules: "*stereotype OR abnormal OR unusual OR behaviour AND Macaca fascicularis OR long-tailed macaque OR cynomolgus macaque OR crab-eating macaque*". The mini-review result was categorised as the following parameters: author and year of publication, the number of individuals observed, stereotype and abnormal behaviour types, and origin or former sources if the research in the captive or detailed for the origin to the housed. The exhibiting of stereotyped and abnormal behaviour was categorised as ethogram locomotive or motor stereotype, self-directed behaviour, and appetitive behaviour; these categorised were adopted from the previous research (C. Lutz et al., 2003; C. K. Lutz, 2018). If the reported exhibited more than one stereotype or abnormal behaviour, then the highest percentage or frequency of the stereotype and abnormal behaviour was used. The sex or gender was ignored because this study only reported what types of exhibiting

stereotypes and abnormal behaviour, as well as for discussion related to their welfare and sustainability.

Data Analysis

After all scientific publications were collected for the mini-review, statistical analysis was done for the data analysis. The statistical correlation between the number of individuals observed and the year of publication was conducted. The correlation test was used to determine the cost of individuals' needs as an animal model for the research. The regression test was conducted to determine the effects of the number of individuals observed, as well as stereotypes and abnormal behaviour types in long-tailed macaques related to the year of publication. Both variables (the number of individuals and stereotype and abnormal behaviour types) were sorted by rank. Microsoft Excel 2019 was conducted to compute the statistical analysis.

RESULTS AND ANALYSIS

Table 1 explains this study's result based on the categorisation conducted in the methods.

Table 1. Mini-review result of the study.

Author (Year)	Number of individuals observed (n)	Stereotype and Abnormal Behaviour Types	Origin or Former Individual(s)
(Minami, 1996)	65 juveniles	Locomotive	Separated from the mother (Orphaned) and kept with peers
(Kaplan et al., 2002)	25 adults	Locomotive	Imported from Indonesia
(Goossens et al., 2008)	13 adults	Appetitive Behaviour	Housed at the Ethology Station of Utrecht University
(Kaeser et al., 2014)	20 adults	Locomotive	Authorised by the Swiss authority
(Ai, 2015)	47 juveniles	Locomotive	Dancing monkey former
(Li, 2015)	47 juveniles	Locomotive	Dancing monkey former
(Cannon et al., 2016)	7 pre-adults	Locomotive	One was retired from laboratory research, and the other was previously housed
(C. K. Lutz, 2018)	415 juveniles	Locomotive	Mother-reared
(Koyama et al., 2019)	20 juveniles	Locomotive	The breeding facility in Japan, based on biochemical experiments

Based on Table 1, the statistical analysis is done. Figure 1 shows the statistical correlation as well as the cost of individuals needed based on the year of publication.

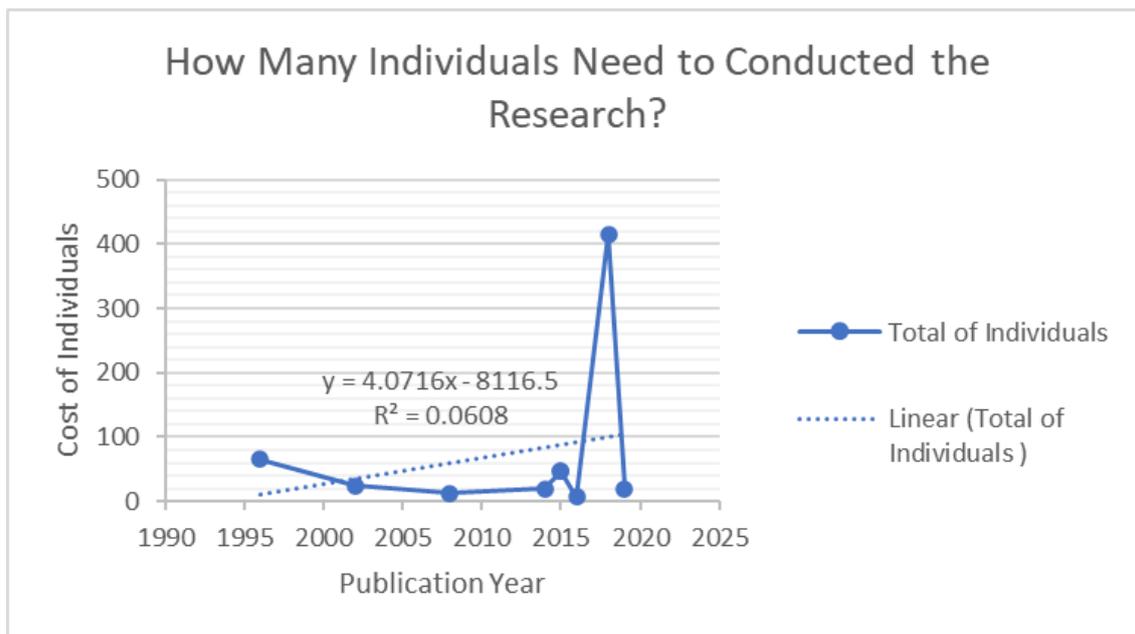


Figure 1. The correlation between the cost of individuals' needs as an animal model for the research and the publication year.

The most important thing for conducting experimental research using animal models is the suitability of the biological aspects related to human conditions. The long-tailed macaque is one of the suitable species for that reason (Sajuthi et al., 2016). Unfortunately, today the IUCN Red-list status of this species is endangered (Hansen et al., 2022). It needs to consider the species' choices for animal model experiment study. The statistical result shows a correlation between the individual cost of this species with the publication year, meaning that the highest cost appears between 2015 and 2020 for the experimental study related to the stereotype and abnormal behaviour of this species. There are many solutions due to reducing the cost of using this species as an animal model, as well as alternatively using related macaque species, including pig-tailed macaque (*Macaca nemestrina*) (Andersen et al., 1994), Japanese macaque (*Macaca fuscata*) (Kawai et al., 2020), and rhesus macaque (*Macaca mulatta*) (Gaglio et al., 2002; Rossion & Taubert, 2019). In addition, if the study is related to dry-material experimental (not using fresh biological samples), such as genetic resources, the free-online gene bank or related genetic host can be used (Al Hakim, Nasution, Rukayah, et al., 2022). Given its current endangered status, it is no longer new to contribute to this species' success in conservation efforts.

The regression test result shows that the total number of individuals observed was significantly different ($p\text{-value} = 0.04 < 0.05$, one-tailed) between stereotype and abnormal behaviour types that appear in the research. Table 2 shows the summary of the regression test result.

Table 2. The summary of the regression test result of this study.

Test	Standard Error	t-stat	p-value*	Lower 95%	Upper 95%
Total Number of Individuals Observed– Stereotype and Abnormal Behaviour Types	3.301785	2.498648	0.041073	0.442519	16.05748

*Note: $p\text{-value} < 0.05$, one-tailed.

The regression result shows a significant difference ($p\text{-value} < 0.05$, one-tailed) regarding the total number of individuals observed, as well as the kind of stereotype and abnormal behaviour types, including locomotive and appetitive behaviour. This study report that all the publications expressed at least one of the stereotype and abnormal behaviour (locomotive or appetitive behaviour). Each individual used in the research of stereotypes and abnormal behaviours allows one to exhibit the intention of the behaviour that the researcher aims for, in this case, including stereotypes and abnormal behaviours. Hence, it is improbable that individuals express normal behaviour.

The highest behaviour reported from all publications cited is locomotive, which is meaningful for the researcher to conduct the commons stereotype and abnormal behaviour exhibited in locomotive type. Besides, based on the review result found that the factor related to stereotypes and abnormal behaviour exhibited, such as former or origin of species adoption (from *Topeng Monyet* or dancing monkey) (Ai, 2015; Li, 2015), behavioural experiment study (Goossens et al., 2008; Kaeser et al., 2014), social manipulation (Kaplan et al., 2002; C. K. Lutz, 2018; Minami, 1996), and environmental enrichment manipulation (Cannon et al., 2016; Koyama et al., 2019). Based on these

references, behavioural experiments, social manipulation, and environmental enrichment manipulation are explicitly used for environmental enrichment stimuli. Indeed, these three origins of species adoption, as well as the study purposes, must be considered for the environmental enrichment condition. The main focus for stimulating environmental enrichment is to provide comfortable opportunities for animals according to the object of treatment in the research provided, as well as prioritizing animal welfare and supporting research success (Hannibal et al., 2017; C. K. Lutz & Novak, 2005; Wolfensohn & Honess, 2005).

CONCLUSION AND RECOMMENDATION

Based on these publications, environmental enrichment stimuli are explicitly employed in behavioural research, social manipulation, and environmental manipulation. The primary goal of stimulating environmental enrichment is to give pleasant options for animals based on the treatment object in the study supplied while emphasising animal welfare and promoting research effectiveness.

This study is not eligible for ethical clearance, which is only a mini-review to provide a scientific phenomenon of stereotypes and abnormal behaviour in primates, so further studies need to be carried out due to the limited study of this species. All authors state there is no conflict of interest.

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REFERENCES

- Abee, C. R., Mansfield, K., Tardif, S., & Morris, T. (2012). Nonhuman Primates in Biomedical Research Volume 1: Biology and Management. In *American College of Laboratory Animal Medicine Series* (2nd ed.). Academic Press. <https://doi.org/10.1016/b978-0-12-373898-1.50036-x>
- Ai, D. T. A. (2015). Karakter Dominansi dan Perilaku Stereotipe pada Monyet Ekor Panjang (*Macaca fascicularis*) Sitaan Serta Saran-Saran Pengelolaannya. *Thesis*.

Institut Pertanian Bogor.

- Al Hakim, R. R., Imtiyaz, C. D., Setyawaty, D., Rahayu, F., & Rianti, P. (2022). Daily Behaviour of Long-tailed Macaque in the Captive, Semi-wild, and Wild Habitats: Preliminary Reports. *Indonesian Journal of Primatology*, 1(01), 25–32. <https://journal.ipb.ac.id/index.php/primatology/article/view/43749>
- Al Hakim, R. R., Nasution, E. K., & Rukayah, S. (2022). PENGGUNAAN *Macaca fascicularis* SEBAGAI HEWAN MODEL PENGEMBANGAN VAKSIN SELAMA KURUN WAKTU 2011-2021: MINI-REVIEW. *Indonesian Journal of Health and Medical*, 2(1), 1–9. <http://ijohm.rcipublisher.org/index.php/ijohm/article/view/87>
- Al Hakim, R. R., Nasution, E. K., Rukayah, S., Putri, E. R. C., & Riani, S. (2022). A review of bioinformatics for primatologists: A note for reducing living primate model and supporting the conservation. *Journal of Advanced Health Informatics Research (JAHIR)*, 1(1).
- Al Hakim, R. R., Satria, M. H., Arief, Y. Z., Pangestu, A., Jaenul, A., Hertin, R. D., & Nugraha, D. (2021). Aplikasi Algoritma Dijkstra dalam Penyelesaian Berbagai Masalah. *EXPERT: Jurnal Manajemen Sistem Informasi Dan Teknologi*, 11(1), 42–47. <https://doi.org/10.36448/expert.v11i1.1939>
- Andersen, D. M., Agy, M. B., Bowden, D., Morton, W. R., & Liggitt, H. D. (1994). HIV infection in non-human primates: the *Macaca nemestrina* model. *Virus Research*, 32(2), 269–282. [https://doi.org/10.1016/0168-1702\(94\)90045-0](https://doi.org/10.1016/0168-1702(94)90045-0)
- Berkson, G., Goodrich, J., & Kraft, I. (1966). ABNORMAL STEREOTYPED MOVEMENTS OF MARMOSSETS. *Perceptual and Motor Skills*, 23(2), 491–498. <https://doi.org/10.2466/PMS.1966.23.2.491>
- Birkett, L. P., & Newton-Fisher, N. E. (2011). How abnormal is the behaviour of captive, zoo-living chimpanzees? *PLoS ONE*, 6(6). <https://doi.org/10.1371/journal.pone.0020101>
- Cannon, T. H., Heistermann, M., Hankison, S. J., Hockings, K. J., & McLennan, M. R. (2016). Tailored Enrichment Strategies and Stereotypic Behavior in Captive Individually Housed Macaques (*Macaca* spp.). *Journal of Applied Animal Welfare Science*, 19(2), 171–182. <https://doi.org/10.1080/10888705.2015.1126786>
- Gaglio, P. J., Liu, H., Dash, S., Cheng, S., Dunne, B., Ratterree, M., Baskin, G., Blanchard, J., Bohm, R., Theise, N. D., & LaBrecque, D. (2002). Liver regeneration investigated in a non-human primate model (*Macaca mulatta*). *Journal of Hepatology*, 37(5), 625–632. [https://doi.org/10.1016/S0168-8278\(02\)00262-3](https://doi.org/10.1016/S0168-8278(02)00262-3)
- Garner, J. P. (2005). Stereotypies and other abnormal repetitive behaviors: Potential impact on validity, reliability, and replicability of scientific outcomes. *ILAR Journal*, 46(2), 106–117. <https://doi.org/10.1093/ILAR.46.2.106>
- Goossens, B. M. A., Dekleva, M., Reader, S. M., Sterck, E. H. M., & Bolhuis, J. J. (2008). Gaze following in monkeys is modulated by observed facial expressions. *Animal Behaviour*, 75(5), 1673–1681. <https://doi.org/10.1016/j.anbehav.2007.10.020>
- Hannibal, D. L., Bliss-Moreau, E., Vandeleest, J., McCowan, B., & Capitanio, J. (2017). Laboratory rhesus macaque social housing and social changes: Implications for

- research. *American Journal of Primatology*, 79(1), 1–14. <https://doi.org/10.1002/ajp.22528>
- Hansen, F. M., Ang, A., Trinh, T., Sy, E., Paramasiwam, S., Ahmed, T., Dimalibot, J., Jones-Engel, L., Ruppert, N., Griffioen, C., Lwin, N., Phiapalath, P., Gray, R., Kite, S., Doak, N., Nijman, V., Fuentes, A., & Gumert, M. D. (2022). *Macaca fascicularis*. *The IUCN Red List of Threatened Species*. e.T12551A1. <https://doi.org/10.2305/IUCN.UK.2022-1.RLTS.T12551A199563077.en>
- Hosey, G. R. (2005). How does the zoo environment affect the behaviour of captive primates? *Applied Animal Behaviour Science*, 90(2), 107–129. <https://doi.org/10.1016/J.APPLANIM.2004.08.015>
- Jacobson, S. L., Ross, S. R., & Bloomsmith, M. A. (2016). Characterizing abnormal behavior in a large population of zoo-housed chimpanzees: Prevalence and potential influencing factors. *PeerJ*, 4(e2225), 1–14. <https://doi.org/10.7717/peerj.2225>
- Kaesler, M., Chatagny, P., Gindrat, A.-D., Savidan, J., Badoud, S., Fregosi, M., Moret, V., Roulin, C., Schmidlin, E., & Rouiller, E. M. (2014). Variability of manual dexterity performance in non-human primates (*Macaca fascicularis*). *International Journal of Comparative Psychology*, 27(2), 295–325. <https://www.researchgate.net/publication/271209071>
- Kaplan, J. R., Manuck, S. B., Fontenot, M. B., & Mann, J. J. (2002). Central Nervous System Monoamine Correlates of Social Dominance in Cynomolgus Monkeys (*Macaca fascicularis*). *Neuropsychopharmacology*, 26(4), 431–443. [https://doi.org/10.1016/S0893-133X\(01\)00344-X](https://doi.org/10.1016/S0893-133X(01)00344-X)
- Kawai, S., Annoura, T., Araki, T., Shiogama, Y., Soma, S., Takano, J. ichiro, Sato, M. O., Kaneko, O., Yasutomi, Y., & Chigusa, Y. (2020). Development of an effective alternative model for in vivo hypnozoite-induced relapse infection: A Japanese macaque (*Macaca fuscata*) model experimentally infected with Plasmodium cynomolgi. *Parasitology International*, 76, 102096. <https://doi.org/10.1016/J.PARINT.2020.102096>
- Kerridge, F. J. (2005). Environmental enrichment to address behavioral differences between wild and captive black-and-white ruffed lemurs (*Varecia variegata*). *American Journal of Primatology*, 66(1), 71–84. <https://doi.org/10.1002/AJP.20128>
- Koyama, H., Tachibana, Y., Takaura, K., Takemoto, S., Morii, K., Wada, S., Kaneko, H., Kimura, M., & Toyoda, A. (2019). Effects of housing conditions on behaviors and biochemical parameters in juvenile cynomolgus monkeys (*Macaca fascicularis*). *Experimental Animals*, 68(2), 195–211. <https://doi.org/10.1538/EXPANIM.18-0114>
- Li, K. J. K. (2015). *Proyeksi Anomali Perilaku Stereotipe Monyet Ekor Panjang (Macaca fascicularis) Sitaan Sebagai Hewan Model Neuropsikopatologi*. Thesis. Institut Pertanian Bogor.
- Lutz, C. K. (2018). A cross-species comparison of abnormal behavior in three species of singly-housed old world monkeys. *Applied Animal Behaviour Science*, 199, 52–58. <https://doi.org/10.1016/j.applanim.2017.10.010>
- Lutz, C. K., & Novak, M. A. (2005). Environmental enrichment for nonhuman primates: Theory and application. *ILAR Journal*, 46(2), 178–191.

<https://doi.org/10.1093/ilar.46.2.178>

- Lutz, C., Well, A., & Novak, M. (2003). Stereotypic and self-injurious behavior in rhesus macaques: A survey and retrospective analysis of environment and early experience. *American Journal of Primatology*, 60(1), 1–15. <https://doi.org/10.1002/AJP.10075>
- Mallapur, A., & Choudhury, B. C. (2003). Behavioral Abnormalities in Captive Nonhuman Primates. *Journal of Applied Animal Welfare Science*, 6(4), 275–284. https://doi.org/10.1207/S15327604JAWS0604_2
- Mason, G., & Rushen, J. (2006). *Stereotypic animal behaviour: Fundamentals and applications to welfare* (2nd ed.). CABI.
- Minami, T. (1996). Locomotive stereotyped behavior in cynomolgus macaques, *Macaca fascicularis*. *Perceptual and Motor Skills*, 83, 935–938. <https://doi.org/10.2466/pms.1996.83.3.935>
- Paulk, H. H., Dienske, H., & Ribbens, L. G. (1977). Abnormal behavior in relation to cage size in rhesus monkeys. *Journal of Abnormal Psychology*, 86(1), 87–92. <https://doi.org/10.1037/0021-843X.86.1.87>
- Rossion, B., & Taubert, J. (2019). What can we learn about human individual face recognition from experimental studies in monkeys? *Vision Research*, 157, 142–158. <https://doi.org/10.1016/j.visres.2018.03.012>
- Sajuthi, D., Astuti, D. A., Perwitasari-Farajallah, D., Iskandar, E., Sulistiawati, E., Suparto, I. H., & Kyes, R. C. (2016). *Hewan Model Satwa Primata Macaca fascicularis: Kajian Populasi, Tingkah laku, Status Nutrien, dan Nutrisi untuk Model Penyakit* (1st ed.). IPB Press.
- Trollope, J. (1977). A preliminary survey of behavioural stereotypes in captive primates. *Laboratory Animals*, 11(3), 195–196. <https://doi.org/10.1258/00236777780936666>
- Vandeleest, J. J., McCowan, B., & Capitano, J. P. (2011). Early rearing interacts with temperament and housing to influence the risk for motor stereotypy in rhesus monkeys (*Macaca mulatta*). *Applied Animal Behaviour Science*, 132(1–2), 81–89. <https://doi.org/10.1016/j.applanim.2011.02.010>
- Wolfensohn, S., & Honess, P. (2005). *Handbook of Primate Husbandry and Welfare*. Blackwell Publishing. <https://doi.org/10.1002/9780470752951>