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Population behavior of *Macaca fascicularis:* An analysis of environmental and social interactions shaping in the Terawang Cave habitat, Central Java

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Abstract: This study aims to identify and analyze the behavior of the population of Long-Tailed Macaque (LTM) in Terawang Cave and to evaluate the influence of environmental factors in the form of temperature, humidity, and light intensity on these behavioral variations At the research location, there were three groups of LTMs, but the sample was the group closest to the cave of 10 individuals. %. LTM behavior is measured using quantitative surveys and scan sampling methods. Observations were made on 6 LTM behaviors and three climatic data (temperature, humidity, and light intensity) in the Terawang Cave environment. There are six types of behavior: mating behavior at 1.87%, agonistic behavior at 10.13%, affiliative behavior at 14.76%, playing behavior at 17.89%, resting behavior at 21.05%, and ingestion behavior at 34.30%. The higher the temperature in the Terawang Cave environment, the lower the LTM activity. The higher the humidity, the higher the MEP activity. Meanwhile, MEP behavior activity increased at medium light intensity. The Canonical Correspondence Analysis (CCA) shows that temperature, humidity, and light intensity influence macaque behavior, with higher temperatures increasing resting, mating activity is more common in humid conditions, playing more in lower light, and ingestion depending on light intensity. In contrast, affiliating behavior is mainly driven by social interactions, highlighting the impact of environmental factors and human activities on macaques, which is essential for conservation efforts.

Keywords: Long-tailed Macaque, behavior, primates

Abstrak: Tujuan dari penelitian ini adalah untuk mengidentifikasi dan menganalisis perilaku populasi Monyet Ekor Panjang (MEP) di Gua Terawang, serta mengevaluasi pengaruh faktor lingkungan berupa suhu, kelembaban, dan intensitas cahaya terhadap variasi perilaku tersebut. Pada lokasi penelitian terdapat tiga kelompok MEP, akan tetapi yang diljadikam sampel adalah kelompok yang paling dekat dengan Gua sejumlah 10 individu. Perilaku MEP diukur menggunakan pendekatan kuantitatif dengan teknik survei dan metode pengambilan sampel pemindaian (scan sampling). Pengamatan dilakukan terhadap 6 perilaku MEP dan tiga data iklim (suhu, kelembaban, dan intensitas cahaya) di lingkungan Gua Terawang. Ada enam jenis perilaku: perilaku seksual sebesar 1,87%, perilaku agonistik sebesar 10,13%, perilaku afiliatif sebesar 14,76%, perilaku bermain sebesar 17,89%, perilaku istirahat sebesar 21,05% dan perilaku makan sebesar 34,30%. Semakin tinggi suhu di lingkungan Gua Terawang, semakin rendah aktivitas MEP. Semakin tinggi kelembaban, semakin tinggi aktivitas MEP. Sementara itu, aktivitas perilaku MEP meningkat pada intensitas cahaya sedang. Analisis Korespondensi Kanonik (CCA) menunjukkan bahwa suhu, kelembaban, dan intensitas cahaya memengaruhi perilaku MEP, dengan suhu yang lebih tinggi meningkatkan perilaku istirahat, aktivitas seksual lebih umum dalam kondisi lembab, bermain lebih sering terjadi dalam cahaya rendah, dan makan bergantung pada intensitas cahaya, sementara perilaku afiliatif terutama didorong oleh interaksi sosial, menyoroti dampak faktor lingkungan dan aktivitas manusia pada MEP, yang penting untuk upaya konservasi.

Kata kunci: Monyet ekor panjang, perilaku, primata

INTRODUCTION

Highlighting its significant primate diversity, Indonesia harbors 60 species distributed across its islands (Jefsykinov et al., 2021), with a remarkable 29 being endemic and belonging to five families: Lorisidae, Tarsiidae, Cercopithecidae, Hylobatidae, and Hominidae. Of the total distribution of primates in Indonesia, Sumatra Island has the most primates. One of the primates that live in Indonesia which has a reasonably wide distribution are the Long-tailed Macaque (*Macaca fascicularis*). According to Maharadatunkamsi et al. (2020) this long-tailed macaque is one of five primate species living on Java Island.

Even though LTM (Long-tailed Macaque) is not included in the protected animal category by the Minister of the Environment and Forestry Regulation Number (P.016/MENLHK/SETJEN/KUM.1/12/2018), MEP has been included in the Endangered species category since March 7, 2022, by the IUCN (International Union for Conservation of Nature) Red List of *Macaca fascicularis* (Hansen et al., 2022). This precarious status makes LTM very likely to become extinct shortly. In addition, CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) includes MEP in the Appendix II group (Nurwahid & Nizar, 2018). This Appendix II group means that if trade or use of MEP is not controlled, MEP can be threatened with extinction (Prawignyo & Ruhaeni, 2018). Appendix II is a situation where more than 30,000 species of animals and plants are regulated and monitored for international trade. As a member of the conservation countries, CITES requires Indonesia to record and report trade in animals and plants included in the Appendix II category, including LTM (Zakariya, 2021). The management authority in Indonesia that regulates the animal and plant export-import scheme for the Appendix II category is the Directorate General of Conservation of Natural Resources and Ecosystems, Ministry of Environment and Forestry (Dirjen KSDHE KLHK) (Zakariya, 2021). Thus, the conservation status of MEP in Indonesia is still not protected because of its wide distribution. However, in the world, MEP is in a position where it is very likely to become extinct soon.

Long-tailed macaques (*Macaca fascicularis*) are spread worldwide in various countries, especially in some areas of Southeast Asian countries. According to the latest data from gbif.org, the distribution of *Macaca fascicularis* is spread in various countries such as Indonesia, Singapore, Thailand, Laos Malaysia, Brunei Darussalam, Cambodia, Vietnam, Philippines, Timor Leste (GBIF Secretariat, 2022). In some of these countries, there are about 9 subspecies of LTM, with 6 of them in Indonesia (Hansen et al., 2021). Meanwhile, in Indonesia, long-tailed macaques are spread across Sumatra, Kalimantan, Java, Bali, West Nusa Tenggara, and East Nusa Tenggara (Maharadatunkamsi et al., 2020).

Maharadatunkamsi et al. (2020) state that LTM can live in various habitats: primary forest, secondary forest, plantation land, agricultural land, mangrove forests, and coastal areas. Long-tailed macaques (*Macaca fascicularis*) also have characteristics that determine their habitat. Nasution and Rukayah (2020) stated that LTM considers food, safety, and

convenience when choosing a habitat or place to live. In choosing a place to live, LTM chooses a location adjacent to the feed source. Choosing a location close to this food source will make it easier for LTM to find food. Meanwhile, regarding security, LTM decides on a safe place to live away from predator threats and attacks (Nasution & Rukayah, 2020). One of the places that became the habitat of LTM is the Terawang Cave.

The Blora Regency Government (2019), in the Feasibility Study Investment Profile Document Final Report: Case Study for the Development of the Greneng Reservoir, states that Terawang Cave is one of six natural tourism areas in Blora Regency. Apart from being a tourist spot in Blora regency, Terawang Cave is also a natural habitat for Long-Tailed Macaques. There are about three LTM groups, each comprising 10–40 MEPs. As a tourist spot, LTM allows for interaction between LTM and visitors. Every LTM that lives in the Terawang Cave has different behaviours, ranging from friendly to behaviour that can attack visitors to the Terawang Cave. Terawang Cave tourists must understand this behaviour to still enjoy its beauty. However, they can still be guarded against the behaviour of the Long-Tailed Macaque that also lives around the Terawang Cave. Moreover, adult and underage tourists, such as kindergarten, elementary, middle, and high school children, visit there.

Based on the background above, this study aims to identify and analyze the behavior of the population of long-tailed monkeys (*Macaca fascicularis*) in Terawang Cave and evaluate the influence of environmental factors in the form of temperature, humidity, and light intensity on these behavioral variations. In addition, this study also aims to understand the relationship between social behavior, ingestion, resting, mating, agonistic, and playing with microclimatic conditions in their natural habitat, to support conservation efforts and management of long-tailed monkey populations in the region. Based on this background, the results of this study are expected to provide information about the behavior of long-tailed monkeys that can be used as a source of Biology learning, especially in animal behavior materials at the high school and university levels.

METHOD

This research uses a quantitative approach with survey techniques and scan sampling methods. In this study, the survey was conducted directly on the research object. At the same time, the scan sampling method was used to calculate LTM behaviours adapted from (Azwir et al., 2022; Ramadhan et al., 2023; Xu et al., 2012) which included social behaviour, mating behaviour, ingestion behaviour (looking for food and eating), playing behaviour (hanging and romping), and resting behaviour (sitting and sleeping). Social behaviour includes agonistic behaviour (angry, chasing, fighting) and affiliative behaviour (cleaning dust or dirt and looking for fleas). These behaviours were observed every 1 hour at 07.00-17.00 WIB. This observation was carried out for 14 days (8-21 April 2023), with seven days of habituation and 7 days of observing LTM behaviour. In addition to observing the behaviour of LTM, observations were made on climatic data from the Terawang Cave environment. The climatic

data observed are temperature, air humidity, and light intensity (Chantika et al., 2023; Pratama et al., 2022).

The population in this study was all Long-Tailed Macaques in Terawang Cave, Blora, Central Java, totalling three groups with around 10-40 individuals in each group. The samples to be studied were Long-Tailed Macaques (*Macaca fascicularis*) in a group of 10 LTMs consisting of three adult males, three female males, two juvenile males, and two juvenile females who interacted with each other in Terawang Cave. The tools and materials used in this study were stationery, observation tables, exam boards, smartphones, cameras, Thermo-Hygrometers, and Lux Meters. While the data analysis used is quantitative data analysis, the formula used to calculate the percentage of long-tailed macaque behaviour is as follows (Ariani et al., 2020):

$$\text{Behaviour} = \frac{\text{Activity Frequency}}{\text{Frequency of All Activities}} \times 100\% \quad (1)$$

Preliminary surveys were carried out before the implementation of the research, which aims to determine the location and the object of the research. This preliminary survey included a literature study, discussions with KPH Blora as the person in charge of Terawang Cave management, and a direct survey at the research location. The implementation of this study began with habituation carried out by researchers at the observation site for seven days. During the 7 days of habituation, the observer slowly approaches the long-tailed monkey from a safe distance so that the monkey gets used to the presence of humans without feeling threatened. 14 days of observation on the long-tailed macaque population in Terawang Cave, where participants were to observe without disturbing the activities of the monkeys and keep a distance with silence and short duration so that natural behaviors remain.

Further processing of data gained from observations was subsequently conducted using the behavioral percentage density formula to compute the behavioral performance of all categories within a long-tailed monkey population. Additionally, the data were subject to further analysis via Canonical Correspondence Analysis (CCA) to determine relationships between monkey behaviors and other environmental factors such as temperature, humidity, and light intensity. CCA was done using PAST V4.13 (Paleontological Statistics) software as a visual aid to display the relationship between environmental variables and behaviors. For other visual data, namely line charts and pie charts, we use RStudio software. The output of this analysis is described in detail in a digital book that is available to readers with access anytime and anywhere.

RESULTS AND DISCUSSION

The research results are LTM behaviour in Terawang Cave, which includes agonistic, affiliative, playing, mating, and resting behaviour. The frequency of six LTM behaviours in the Terawang Cave for seven days can be seen in Table 1. The total frequency of each LTM

behaviour in the Terawang Cave was then calculated using the Long-tailed Macaque behaviour percentage formula. The percentage of LTM behaviour in the Terawang Cave can be seen in Figure 1.

Figure 1. The resting behavior of LTM groups in Terawang Cave.

Figure 1 shows several LTMs resting in one of the visitor facilities in Terawang Cave. It is also important to see how the LTM's circadian rhythm and subsequent behavior will be observed.

Table 1. Frequency of long-tailed Macaque behavior in the Terawang Cave

Days to-	Agonistic	Playing	Mating	Ingestion	Affiliative	Resting	Amount	Average
1	78	95	13	168	82	110	546	91.00±50.28
2	57	97	6	186	54	108	508	84.67±61.42
3	62	107	16	186	71	110	552	92.00±57.45
4	42	91	12	179	75	110	509	84.83±57.92
5	50	87	5	169	69	110	490	81.67±55.68
6	41	92	10	190	89	109	531	88,50±61.89
7	39	83	6	172	98	110	508	84,67±57.83
Amount	369	652	68	1250	538	767	3644	
Average	52.71± 14.09	93.14± 7.71	9.71± 4.19	178.57± 9.02	76.86± 14.39	109.57 ± 0.79		

Based on the data frequency of the LTM, Figure 2 shows the difference in the percentage of each behavior. Based on Figure 2, ingestion behaviour has a percentage of 34.30%, consisting of food-seeking and ingestion behaviour. The form of food-seeking behaviour carried out by LTM in Terawang Cave for seven days of observation was almost the same every day, namely looking for food by scavenging on the ground, looking for food in trees, garbage cans in Terawang Cave, and looking for corn and banana gardens owned by residents. For seven days, LTM's food-seeking behaviour in Terawang Cave was observed by looking for food, sniffing it, putting it in his mouth, and collecting it first. The first behaviour of collecting food into his mouth is to collect as much food as possible. In general, LTMs tend to control as much food as possible, even though they cannot finish the food (Winarno & Harianto, 2018).

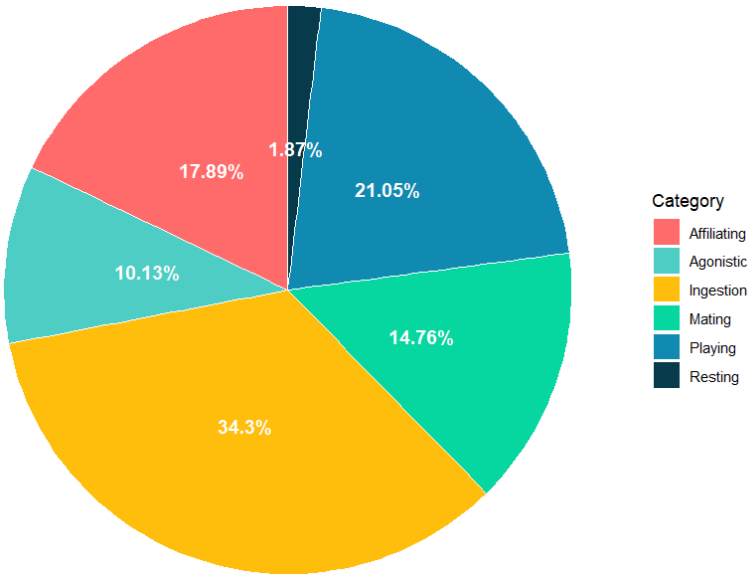

Figure 2. Percentage of LTM behaviour in Terawang Cave

LTM's ingestion behavior at Terawang Cave is the same every day; LTM will eat leftovers from visitors to Terawang Cave in trash cans and on the ground. LTM also eats leaves, fruit, and insects found in trees or on the floor. In addition, LTM in Terawang Cave also ate food provided by visitors and managers of the Terawang Cave, such as peanuts, corn, bananas, snacks, and so on; even LTM in Terawang Cave ate food stolen from traders there. When it was time for the manager to provide food or visitors were providing food, there was a struggle for food between one LTM and another LTM, so fights often occurred between LTM. During the seven days of observation, LTM seemed to take food several times without chewing it directly. LTM in Terawang Cave, when visitors and managers of Terawang Cave were given food such as peanuts, they appeared to put the food in their mouths, then moved places, took the peanuts back out, and pried and chewed them. The process of LTM ingestion behavior in Terawang Cave is the same as that by Winarno and Harianto (2018). LTM, under certain circumstances, will put food into the cheek pouches. This ingestion behavior is also quite dominant, observed in several areas of LTM distribution (Ramadhan et al., 2023). When conditions are safe, the food is taken out again to be chewed and swallowed to be digested (Winarno & Harianto, 2018).

Resting behavior has a percentage of 21.05% with a total frequency of 767 times, consisting of sitting and sleeping behavior. LTM's sitting behavior in Terawang Cave was carried out during free time, namely when eating, looking for food, cleaning dust, and looking for fleas before and after marriage. Sitting behavior accompanied by food-seeking behavior is the same as research conducted by Dahar et al. (2021) in the Ranamese Resort Forest Area, namely, LTM looking for food by sitting on the ends of relatively large branches or twigs. Sitting behavior followed by affiliative behavior, which includes looking for fleas and cleaning dust/dirt, is in line with a study conducted by Pratama et al. (2022), namely that

resting activity is higher in trees and followed by grooming activities and little moving activity. Sleep behavior was carried out by LTM in Terawang Cave at the 8th to 10th hour of observation or at 14.00-17.00 WIB. LTM carried out sleeping behavior in Terawang Cave on trees, rocks, ground, and electric poles, but it was often done in trees. LTM's sleeping behavior is when he seems to close his eyes for a long time by making himself aware of tree branches, electricity poles, the ground surface, or himself. This finding is consistent with previous research, which found that sleeping behavior in this species typically involves sitting with eyes closed or lying down (Azwir et al., 2021; Ratnasari et al., 2019).

Playing behavior has a percentage of 17.89% with a total frequency of 652 times. Playing behavior is divided into two behaviors, namely hanging behavior and chasing behavior. The hanging behavior was carried out by LTM in the Terawang Cave by hanging from the trees, hanging roots that extended downwards, ropes in the playground, and hanging from the power cables in the Terawang Cave. Playing behavior in LTM includes hanging and swinging by gripping tree branches with both feet and suspending the body upside down (Dzulhelmi et al., 2019). LTM teenagers mainly carried out the hanging behavior carried out by LTM in the Terawang Cave. Nasution et al (2021) stated that the younger age group carries out most of the hanging behavior by hanging from branches or hanging roots. In addition, adult LTMs also carry out hanging behavior, namely adult males (Nasution et al., 2021). LTM carried out romp behavior in Terawang Cave by chasing each other without showing an angry attitude, such as showing canines or a distinctive angry sound. The LTM's behavior in Terawang Cave was carried out by chasing each other in their free time, looking for food, and moving places. LTM carried out chasing activities when moving places to look for food, which were carried out by LTM juveniles (Pratama et al., 2022).

Affiliative behavior has a percentage of 14.76% with a frequency of 538 times. Affiliative behavior is divided into two forms of behavior, namely, the behavior of cleaning dust or dirt and the behavior of looking for fleas. The cleaning of dust or dirt by LTM at Terawang Cave looked like taking something or throwing dust or dirt on LTM's own body or another LTM. The probing behavior is in the form of searching activities, picking up dirt found on the body by using the hands or mouth, both towards themselves and others (Fachrozi & Setyawatiningsih, 2020). The behavior of looking for LTM fleas in Terawang Cave was carried out between the hairs on his own body and other LTM's bodies, then put them into his mouth several times. Marsuki (2022) states that cleaning oneself from fleas is also known as grooming behavior. This behavior is divided into two, namely autogrooming, which is carried out on himself, and allogrooming, which is carried out by other individuals. This behavior is carried out by using the fingers to look for them in certain body parts (Marsuki, 2022). Grooming behavior on LTM is carried out by using both hands to pick up, rub, comb, and look for lice in their hair (Winarno & Harianto, 2018).

Agonistic behavior has a percentage of 10.13% with a total frequency of 369 times. Agonistic behavior is divided into three forms, namely angry behavior, chasing, and fighting.

The angry behavior of LTM in the Terawang Cave included anger towards other LTM and anger towards visitors to the Terawang Cave. LTM will behave angrily when it is disturbed by other LTM or visitors to the Terawang Cave. When LTM is angry with another LTM, this behavior continues with chasing behavior and ends with fighting. Whereas when LTM behaves angrily towards visitors to Terawang Cave, it will continue to chase behavior several times. LTM acted angrily in Terawang Cave by showing his canine teeth and making his distinctive angry voice. Several times, LTM will claw or bite visitors.

The agonistic behavior of the LTM in Terawang Cave was triggered by angry behavior towards other LTM and visitors to the Terawang Cave. This chasing behavior ends with clawing and biting visitors and other LTMs, several times ending in fights between LTMs. More than 2 LTM individuals carry out fighting behavior. LTM carried out this fighting behavior in Terawang Cave, where they hit, clawed, and bit each other. Fighting behavior was carried out by LTM on the ground by staring at each other, showing their fangs, and clawing other individuals (Jawadi & Rita, 2019). The fighting behavior of LTM in Terawang Cave is mainly done when fighting over food during ingestion by visitors and managers of Terawang Cave.

Behavior has a total percentage of 1.87% with a total frequency of 68 times. Mating behavior, a form of mating behavior carried out by LTM in Terawang Cave, did not last long, only a few seconds, but several times it could reach 2-3 minutes. Mating behavior can occur for more than 30 seconds to 2 minutes (Nasution & Rukayah, 2020). In general, mating behavior is carried out by adult LTM, both males and females. However, in the observations made in the Terawang Cave, juvenile LTM was also engaged in mating behavior. This mating behavior is carried out by LTM, both adults and juveniles, on the ground or in trees. The marriages among LTM adolescents in Terawang Cave occurred because the age of LTM adolescents ranged from 1-6 years, while 3.5 years of age was sufficient for marriage, even though they had not yet reached the age of mating maturity. LTM reaches the minimum age to marry at 3.5-5 years old. Mating maturity in male long-tailed macaques is 4.2 years, while in females, it is 4.3 years (Munawaroh, 2019).

In addition to measuring the frequency of LTM in the Terawang Cave, measurements of environmental factors were also carried out, which included temperature, air humidity, and light intensity in the Terawang Cave environment to determine the effect of environmental factors on LTM behavior activities in the Terawang Cave. LTM behavior activities that influence environmental factors are active behavior and inactive behavior. Active behavior consists of chasing, anger, fighting, hanging, mating, ingestion, and food-seeking behavior. Behaviors that belong to the resting behavior are cleaning dust or dirt, looking for fleas, sitting, and sleeping. The climatic data measured in this study can be seen in Figure 3.

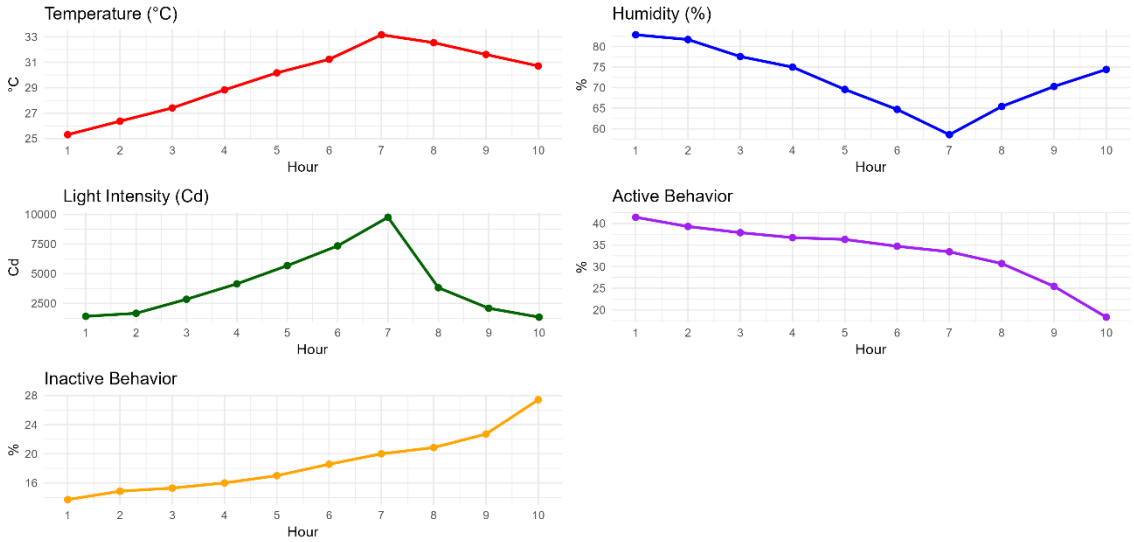

Figure 3. Graphs of average environmental climatic data and LTM active-inactive behavior in the Terawang Cave

The highest average temperature occurred at the 7th hour, namely 33.16°C. The highest increase in average temperature occurred at the 6th to 7th hour, from 31.23°C to 33.16°C. This increase in temperature coincided with an increase in inactive behavior and a decrease in active LTM behavior in the Terawang Cave. This increase in temperature influences the behavior carried out by LTM; high enough temperatures cause more LTM resting behavior (Laynurak, 2022). The resting behavior, included in the LTM inactive behavior, increases by an average of 1.43 times. At the same time, active behavior decreased by an average of 1.29 times. The relatively high temperature during the day LTM behavior decreased, while in the morning, it increased (Pratama et al., 2022). An increase in temperature causes LTM to lose a lot of body energy when it continues to be active, causing LTM's active behavior to decrease and LTM's inactive behavior to storage optimization energy in the body (Dahar et al., 2021).

Air humidity peaks in the first hour at an average of 82.86%, and declines to its lowest average, at 58.57%, during the 7th hour. Between the 6th and 7th hour, air humidity experiences a significant decline of 6.14% on average, which further increases again at the 7th hour by 6.86%. The active behavior of Terawang Cave apparently declines at this hour with the increase of its LTM inactive behavior. Meanwhile, the increased air humidity shows a corresponding increase with the increasing LTM inactive behavior of the Terawang Cave. The activity carried out by LTM was higher in the morning with high humidity. During the day, LTM activity begins to decrease due to a decrease in air humidity, which affects the daily activities of long-tailed macaques (Pratama et al., 2022). In the observations made in Terawang Cave for seven days, more active LTM behavior is carried out in the morning than inactive behavior. Then, towards noon, the active behavior of LTM in Terawang Cave decreases, while the inactive behavior of LTM increases due to a decrease in air humidity

during the day. Chantika et al. (2023) also stated that when the air humidity is high and the temperature is low, the air will feel cold, so the LTM makes more movements.

At the 7th hour, the most significant increase in light intensity was 2411.57 Cd. An increase in average light intensity was correlated with a decrease in average LTM active behavior, while LTM inactive behavior increased in Terawang Cave. The average light intensity enveloping the Terawang Cave showed the greatest incidence of decrease on the 8th hour, reaching down to 5935.86 Cd, from the previous hour, thereby explaining the simultaneous decrease in average light intensity and the increase in average LTM inactivity behavior. When the light intensity was moderate, the activity of long-tailed macaques increased (Pratama et al., 2022). The research was carried out for seven days in Terawang Cave, and the general light intensity was measured at 4011.77 Cd. A moderate light intensity was on from the 4th to the 6th hours of observation, along with increased LTM activity. At the 4th hour, the average LTM activity in Terawang Cave was 52.71 times, whereas the average light intensity for Terawang Cave was recorded at 4146.86 cd. The 5th hour of LTM activity averaged 53.29 times in Terawang Cave, averaging 5680.86 Cd light intensity. During the 6th hour of observation, average LTM activity and its average light intensity showed values of 53.29 times and 7346.14 Cd, respectively. From this, it can be inferred that from the 4th to the 6th hour in Terawang Cave, LTM activity increased with light intensity. A multivariate analysis was carried out using Canonical Correspondence Analysis in Figure 4 to see how behavior is related to environmental factors.

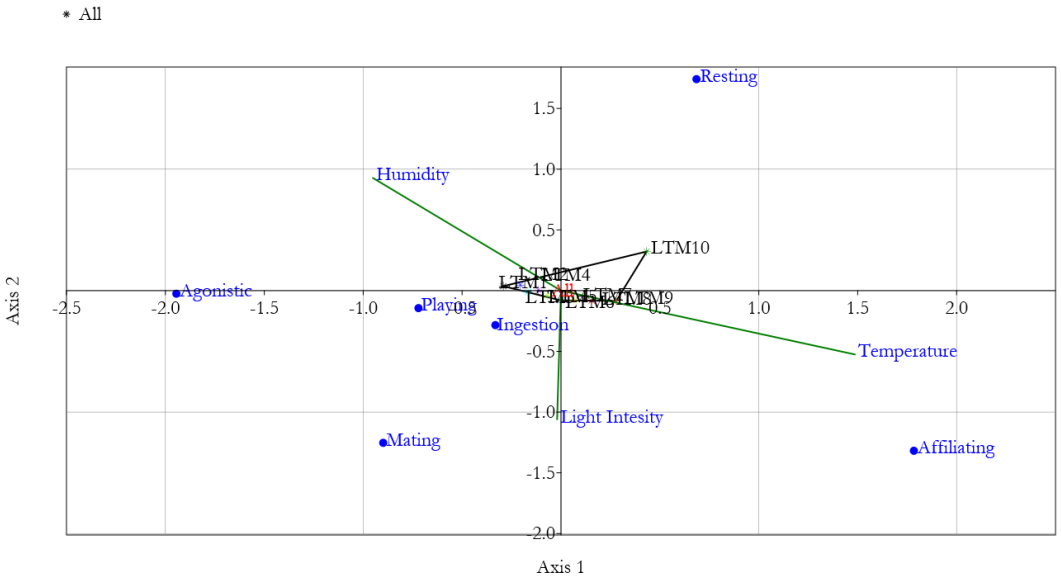

Figure 4. Graph Results of Canonical Correspondence Analysis (CCA)

The Canonical Correspondence Analysis (CCA) illustrated in figure 4 shows the correspondence of environmental factors and patterns of behavior of long-tailed macaques (*Macaca fascicularis*). The diagram mainly consists of two organizing axes denoting data

variation, containing blue points representing behaviors related to monkeys and environmental factors, denoted by green vectors, such as temperature, humidity, light intensity, and light. Positioning of behaviors in this diagram reflects the extent to which different behaviors depend on the individual environment. The closer a behavior is to the direction of an environmental vector, the higher the influence of that factor on the behavior.

The analysis indicates that temperature greatly influences resting behavior. The position of Resting is almost parallel to the temperature vector; thus, it follows that macaques would tend to sleep more at higher temperatures, probably to save energy and spend less time in excess heating. Mating Activity and Play, on the other hand, are related to humidity and light intensity. Mating Activity is positioned closer to the humidity vector, which suggests that macaques are likely to indulge in reproductive behaviors more in humid conditions. In contrast, play activity is well-suited to lower light intensity, probably nudging by the point that macaques are likely to play in dimmer-light conditions, like early morning or late afternoon.

Table 2. Significance test results (p-values) and eigenvalues for CCA axes

	Eigenval	**p. value**
Axis 1	0.0379	0.0297
Axis 2	0.003563	0.1584
Axis 3	8.463E-13	0.9703

Based on the results of the Canonical Correspondence Analysis (CCA) analysis with the measurements used in Table 2, the first axis (Axis 1) shows a statistically significant relationship ($p=0.0297$) between environmental and behavioral variables, although the eigenvalue is relatively small (0.0379), indicating that the first linear combination of ecological variables significantly affects specific behavioral patterns; in contrast, the second axis (Axis 2: $p=0.1584$, eigenvalue=0.003563) and the third axis (Axis 3: $p=0.9703$, eigenvalue=8.463E-13) showed no statistically significant relationship, suggesting that the patterns observed on these axes were most likely due to random variation or the influence of weak environmental variables.

The Affiliative behavior, indicative of social interaction, seems to be more isolated from environmental factors, suggesting that it is propelled more by social context than by alien ecological conditions. On the contrary, the ingestion behavior varies with light intensity, perhaps indicating that macaques carry out foraging when there is enough light, perhaps during the daytime when food sources are most visible. Most importantly, this analysis has exhibited the influence of the environment on the long-tailed macaques' daily activities. Fathoming these relationships could yield insights into further studies on how climate change or perturbations to habitat could disrupt their natural behaviors, thus assisting in conservation and population management strategies in their natural range. In addition, the

behavior of *M. fascicularis* can also be influenced by anthropogenic factors, especially if the location is a tourist attraction (Brotcorne et al., 2020; Marty et al., 2019).

CONCLUSION

Based on the research results, analysis and disscusion, it can be concluded, based on the study, that the most common behavior exhibited by long-tailed macaques (*Macaca fascicularis*) in Terawang Cave is ingestion, which accounts for 34.30% (1250 occurrences), followed by resting, accounting for 21.05% (767 occurrences). Playing amounts to 17.89% (652 occurrences), affiliative behavior 14.76% (538 occurrences), agonistic behavior 10.13% (369 occurrences), and mating behavior 1.87% (68 occurrences). Environmental factors such as light intensity, humidity, and temperature greatly affect macaques' behavior. The Canonical Correspondence Analysis (CCA) suggests that elevated temperatures are associated with greater resting activity and are likely to save energy. Mating and playing activities are more common in humid conditions and reduce light intensity. Affiliative behavior is less affected by environmental factors and is likely affected by social interactions. Ingestive behavior, on the contrary, is regulated through light intensity levels, such that macaques will forage more when enough light is provided. Such findings underscore the applicability of knowledge regarding how the environment regulates macaque behavior toward supporting conservation and management. Behavior in macaques can even be regulated through human activities, especially where humans engage in tourist activities.

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