

A Preliminary Study Of The Javan Leopard (*Panthera pardus* ssp. *melas* G. Cuvier) Behavior In Meru Betiri National Park

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Abstract

Meru Betiri National Park areas in Java that can support a viable Javan leopard population. The Javan leopard has become a priority species for conservation management after the extinction status of the Javan tiger. Therefore, knowing how the Javan Leopard behaves to improve species management is essential. We conducted a field study using camera traps to determine the daily behavior of the Javan leopard in MBNP. There are 52 grids of permanent monitoring sites for the Javan leopard in MBNP; 6 grids were selected as sampling plots in this study. A monitoring site was established with 73 camera stations, with one station covering 0.5 x 0.5 km². Individual identification was conducted with WildID Version 1.0, and ad libitum observations will be used to record all possible behaviors. Behavioral data was analyzed to determine the proportion of behaviors and the frequency. The results indicate that the Javan leopard displays nine daily behaviors: walking, observing, standing, cheek rubbing, scraping, urine spraying, claw marking, parenting, vocalizing, and others. Each behavior was observed with a relative frequency of walking (63.25%), observing (14.53%), standing (7.69%), and others. An analysis of the time spent on each behavior revealed their proportion as follows: walking (382 s, 49.29%), observing (208 s, 26.84%), standing (66 s, 8.52%), and others.

Keywords: Behavior, ethogram, leopard, Meru Betiri National Park

Introduction

Meru Betiri National Park (MBNP, 526 km²), one of the four core areas of UNESCO's Blambangan Biosphere Reserve declared in 2016 and also part of the Ijen Geopark, is one of only three protected areas in Java that can support a viable Javan leopard population. The consideration of the Meru Betiri National Park designation was a habitat for various types of animals. As a wildlife sanctuary, this area is a safe and suitable place for wildlife to live, feed, and breed. Historically, before becoming a National Park, this area was a Wildlife Reserve that was designated and established in 1972 to protect the Javan tiger (*Panthera tigris sondaica*), Javan leopard (*Panthera pardus* ssp. *melas* G. Cuvier, 1809), and various other animals and their habitats (The Ministry of Agriculture, 1972). After the Javan tiger became extinct, the Javan leopard was the feline and also the apex predator (Wibisono et al., 2021; Castelló, 2020), whose role is vital in balancing the ecosystem in the forests of Java Island. The status of the Javan leopard based on the IUCN Red List assessment in 2016 was Critical Endangered (C.R.) and changed in the 2021 assessment to Endangered (EN) (Wibisono et al., 2021).

Javan Leopards were widely distributed across Java Island and several adjacent small islands, including

Nusakambangan and Kangean (Santiapillai & Ramono, 1992; Gunawan et al., 2012; Wibisono et al., 2021). In the MBNP, the Javan leopards are distributed across the central to the eastern and southern parts of the park. There are 34 adult individuals in the park (MBNP Office, 2020). The Javan leopard has become a priority for national park management (Directorate General Natural Resources and Ecosystem Conservation, 2015). As a keystone animal that plays a vital role in maintaining the balance of the forest ecosystem (Caro, 2010; Wallach et al., 2015; Wibisono et al., 2021; Burgos et al., 2024; Qureshi et al., 2024), the Javan leopard is an essential object of study. Numerous significant advantages for conservation and ecological management initiatives arise from the study of leopard behavior. Many studies have demonstrated the value of comprehending leopard movement patterns for risk assessment and the development of successful conservation strategy (Wibisono et al., 2018; Rodríguez - Recio et al., 2022; As'ary et al., 2023; Rostro-García et al., 2024). He is examining individual specialization's role in leopard diets to shed light on population dynamics and interactions within communities (Akrim et al., 2023; Mortelliti, 2023). Moreover, research on the behavior of leopards explains that prey offers valuable insights into the dynamics between prey and predators and is crucial for

developing successful and affordable conservation plans for various environments (Balme et al., 2020; Ariyanto et al., 2024). Therefore, it is essential to understand the behavior of the Javan leopard. This research is the first study of Javan leopard behavior in the MBNP. The study aims to create an ethogram of the Javan Leopard to assist the MBNP managers in conserving this endangered species.

Materials and Methods

This study was observational (Altman, 1974; Breed, 2017; Naguib et al., 2023). The observational sampling method in this study was a modification of the ad libitum sampling (Lehner, 1992; Zimbler-DeLorenzo & Margulis, 2021; Naguib et al., 2023). Camera traps are used to observe the behavior. There are 52 grids (2 x 2 km)

of permanent monitoring sites for the Javan leopard in MBNP. Based on a previous study (MBNP Office, 2020; MBNP Office, 2021), six grids were selected as sampling plots to observe the daily Javan leopard behavior in this study. Data was collected from September to November 2022 at Bandialit Resort and Sukamade Resort MBNP, East Java, Indonesia. A monitoring site was established with 73 stations (sub-grid), with a density of one station per 0.5 x 0.5 km², with the position of the cameras optimized to capture the densities and area coverage (Figure 1). The camera trap was configured to record events of 30 seconds in length with a 2-second delay between events, with the date and time of each event recorded. The cameras remained active 24 hours a day.

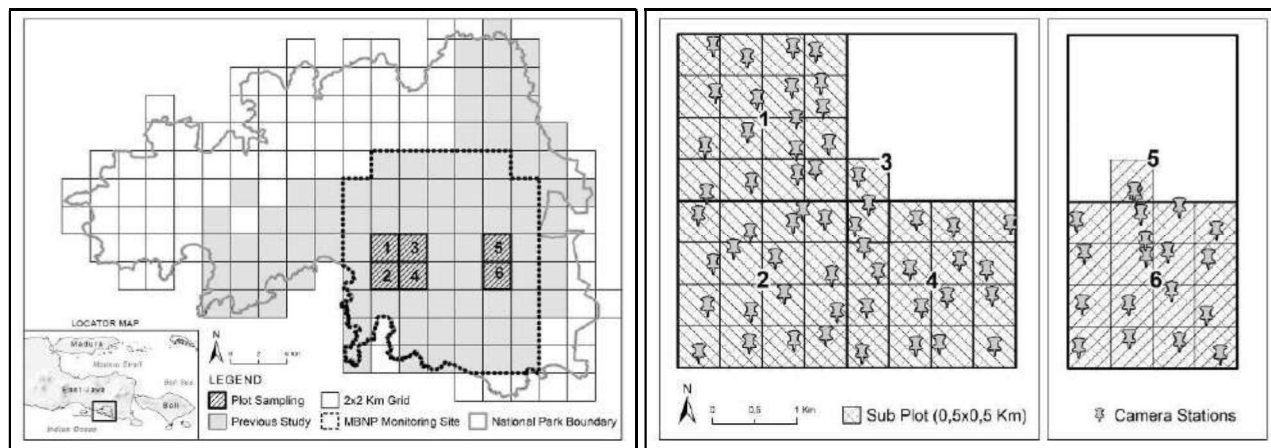


Figure 1. Research station map

The data from the camera traps (photos and videos) were collected in folders according to species. We used WildID Version 1.0 (Bolger et al., 2011; Bolger et al., 2012; Wibisono & Kusuma, 2022) to assist in identifying individual Javan leopards. All Javan leopard behaviors, both event and state, will be recorded and tabulated based on the type of behavior and the duration of each Behavior (Lehner, 1992; Naguib et al., 2023). Behavior refers to the standard ethogram for Felidae (Stanton et al., 2015) and existing research references. The tabulated behavioral data was analyzed to determine the frequency and proportion of behaviors. Ad libitum observations are used to analyze possible behaviors not listed in the ethogram (Lehner, 1992; Naguib et al., 2023). Time of occurrence was grouped into six categories to determine leopard activity based on these categories, including dawn (04.00- 06.00 WIB),

morning (06.00 - 11.00 WIB), afternoon (11.00 - 15.00 WIB), evening (15.00 - 17.00 WIB), dusk (17.00 - 19.00 WIB), and night (19.00 - 04.00 WIB).

Results

Daily Behavior

The Javan leopards were recorded at 34 out of 73 stations that had captured 85 photo/video files of the Javan leopard out of 3,331 photo/video files and identified seven individuals consisting of 3 males and four females (Figure 2). Some records were collected from additional observation stations. We described each observed Javan leopard behavior from the camera trap data into an ethogram of the Javan leopard behavior in MBNP, as shown in Table 1. The time duration and frequency of each behavior of the Javan leopard in MBNP are shown in Table 2).

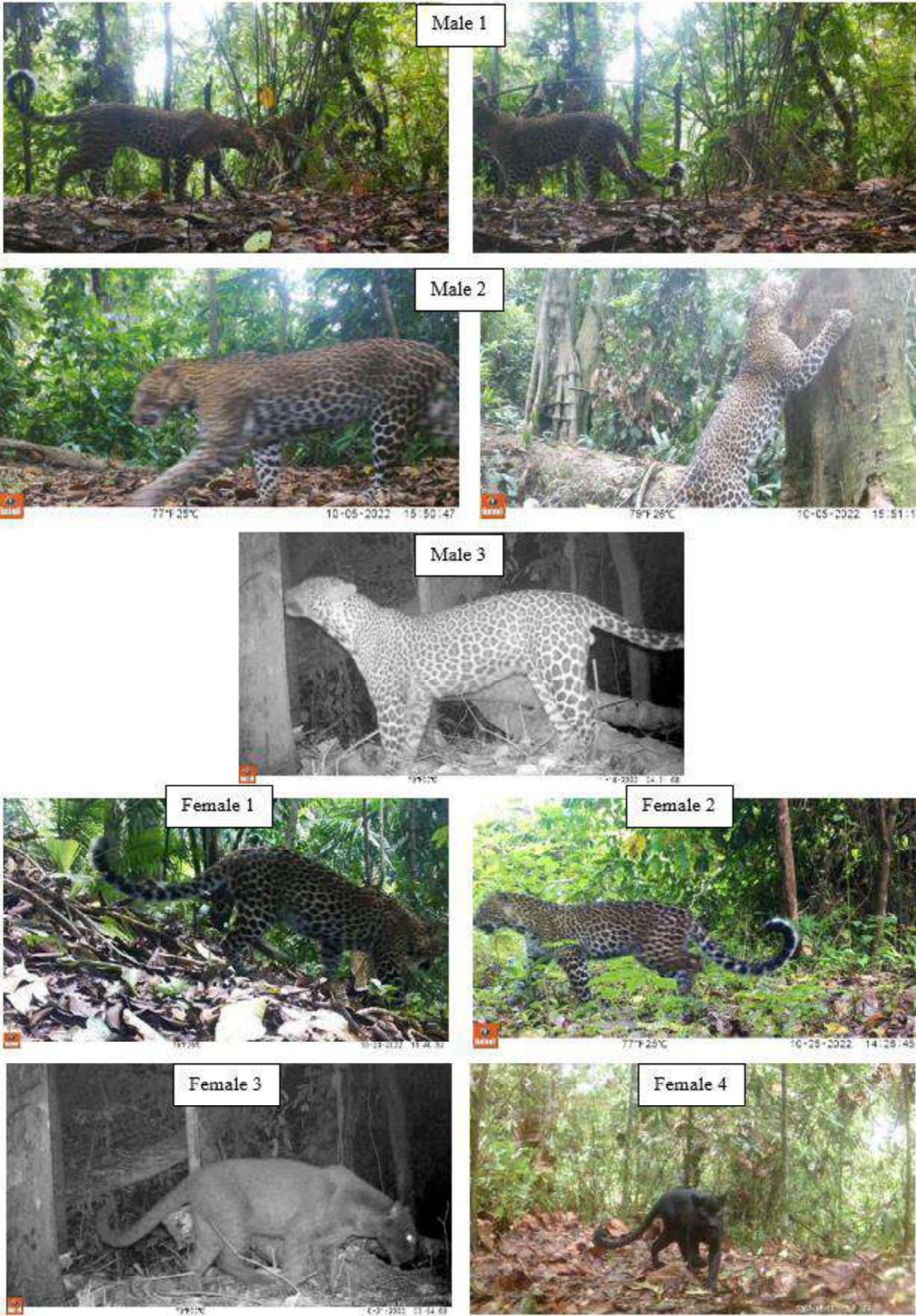


Figure 2. Individual Javan leopards are recognized by this study's spot and rosette pattern/formation

Table 1. Ethogram of the Javan leopard in MBNP (modified from Stanton *et al.*, 2015)

Title	Definition
Clawing / Claw marking	Cat drags front claws along an object or surface, likely leaving visual claw marks.
Head rub/Cheek rub	The cat rubs its head/cheek against (modifier).
Standing	The cat is upright and immobile, with all four paws on the ground and legs extended, supporting the body.
Observe/ Investigate	The cat observes a specific stimulus (or modifier). Cats show attention to a specific stimulus by sniffing and pawing at it.
Urine spray	While standing with its tail raised vertically, the cat releases a jet of urine backward against a vertical surface or object. The tail may quiver as urine is discharged.
Vocalize	Cat produces sounds or calls originating from the throat and mouth.
Walking	Forward locomotion at a slow gait.
Scraping	the act of scraping the surface of the ground with their paws
Parenting	The activity involves bringing up and looking after the young leopard by walking with the young leopard.

The results show that the Javan leopard exhibits five categories and nine types of behaviors, including walking, observing, standing, cheek rubbing, scraping, urine spraying, claw marking, parenting, and vocalizing. Table 2 above shows the Javan leopard's most extended or time-

consuming behaviors. Each behavior was observed with a relative frequency of walking (63.25%), observing (14.53%), standing (7.69%), cheek rubbing (5.98%), scraping (4.27%), urine spraying (1.71%), claw marking (0.85%), parenting (0.85%) and vocalizing (0.85%).

Table 2. Results of recording time duration and frequency of the Javan leopard behavior

Category	Behavior	Duration (s)	%	Frequency (event)	F.R. (%)
A. Marking	1. Cheek rub	27	3,48	7	5,98
	2. Claw mark	4	0,52	1	0,85
	3. Scraping	57	7,35	5	4,27
	4. Urine spraying	17	2,19	2	1,71
B. Moving	5. Walking	382	49,29	74	63,25
C. Socializing	6. Parenting	5	0,65	1	0,85
D. Resting	7. Standing	66	8,52	9	7,69
E. Miscellaneous	8. Observe	208	26,84	17	14,53
	9. Vocalizing	9	1,16	1	0,85

An analysis of the time spent on each behavior revealed their proportion as follows: walking (382 s, 49.29%), watching (208 s, 26.84%), standing (66 s, 8.52%), cheek rubbing (27 s, 3.48%), scraping (57 s, 7.35%), urine spraying (17 s, 2.19%), vocalizing (9 s, 1.16%), claw marking (4 s, 0.52%) and parenting (5 s, 0.65%). The graph of Javan leopard behavior based on time duration and frequency can be seen in Figure 3, while the graph of Javan leopard behavior based on time categories, time duration, and frequency of occurrence can be seen in Figure 4 below.

The Javan leopard was found to be active in all time categories (figure 4). However, based on the duration of time spent, the Javan leopard spent

most of its behavioral time in the evening (200 s), morning (197 s), afternoon (147 s), night (139 s), dawn (59 s) and dusk (33 s). Eight types of Behaviors were recorded in the evening, including cheek rub, claw mark, observing, scraping, standing, urine spraying, vocalizing, and walking. Five types of behavior were recorded in the morning: observing, parenting, scraping, standing, and walking. While at dawn, 4 types of behavior were recorded, including cheek rub, observation, scraping, and walking. Although it has been reported that Javan leopards sleep at dusk for 1 hour and 43 minutes (MBNP Office, 2021), in this study, 4 types of behavior were recorded, including observing, standing, urine spraying, and walking.

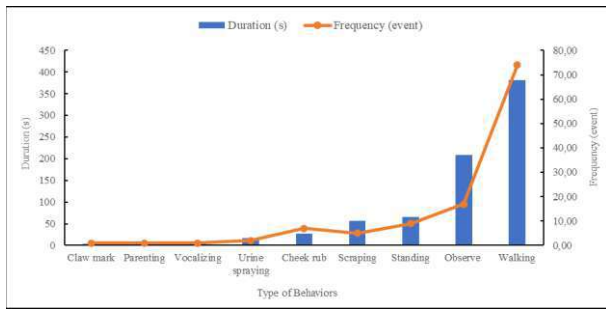


Figure 3. The graph of Javan leopard behavior based on time duration and frequency

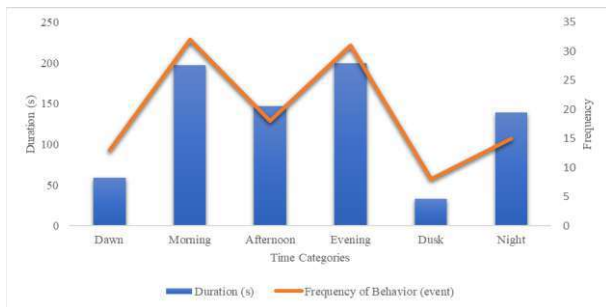


Figure 4. The graph of Javan leopard behavior based on time categories

Movement

Behavior involves static postures and active movements, all the noises and smells, and the changes in color and shape that characterize animal life (Manning & Dawkins, 2012). Leopards use all four of their legs to move around, including walking, running, climbing trees, and jumping (Bailey, 1993; Hunter *et al.*, 2013; Castelló, 2020), also swimmers though they typically avoid water and rarely swim (Guggisberg, 1975; Hunter, 2015; Castelló, 2020). The movement behavior recorded in this study was walking (Figure 5.a). The Javan leopard walks past a camera trap. This walking behavior occurred in all categories: dawn, morning, afternoon, evening, dusk, and night. It was the most frequent behavior and lasted the longest (382 s).

Resting

The Javan leopard rests by remaining motionless, including sleeping, sitting, and stopping walking. The Javan leopard rests on the ground, undercover, or in trees during the day (Bailey, 1993; Castelló, 2020). It has been reported that Javan leopards sleep at dusk (MBNP Office, 2020). This study recorded that the Javan leopard stood still for a moment after walking alone during the night, morning, afternoon, and dusk.



Figure 5. The Javan leopard behavior recorded in this study included (a) walking, (b) urine spraying, (c) Scrapping, (d) observing, (e) cheek rub, (f) claw marking, (g) standing, (h) parenting, and (i) vocalizing

Marking

Javan leopards are territorial and will defend their territory against individuals of the same sex. Forms of marking behavior include scratching/claw marking, scraping, urine spraying, head or cheek rube, etc. (Bailey, 1993; Gunawan & Alikodra, 2013; Hunter *et al.*, 2013; Hunter, 2015; Castelló, 2020). This study recorded that the Javan leopard marked the territory by cheek rub, claw marking, scraping, and urine spraying at dawn, in the morning, afternoon, evening, and dusk.

Socializing

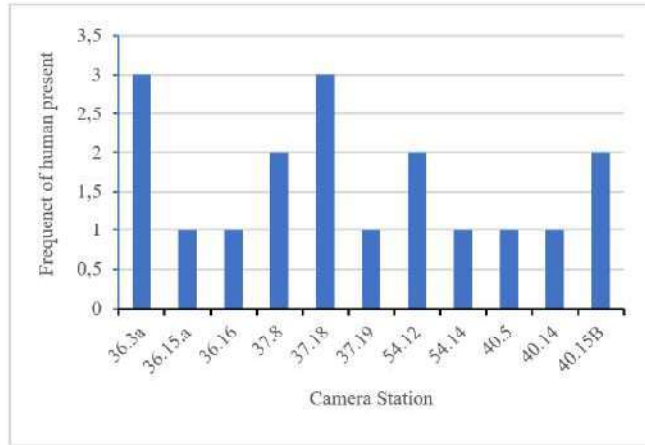
As adults, Javan leopards are typically solitary. However, females may raise cubs, or males and females may briefly associate during courtship (Bailey, 1993; Hunter *et al.*, 2013; Stander *et al.*, 1997; Gunawan & Alikodra, 2013). Our study reveals that the Javan leopard was recorded walking to look after its cubs in the morning.

Miscellaneous

The Javan leopard is often doing other activities that are not included in the previous category or not listed in the ethogram—miscellaneous behavior, including observing all-time categories and vocalizing at dusk. Vocalizing may advertise territory and reproductive availability, and its sound carries to 3 km (Hunter *et al.*, 2013; Hunter, 2015; Gunawan & Alikodra, 2013).

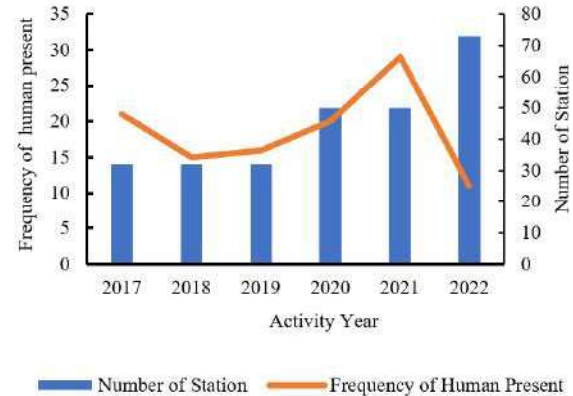
Potential Human Disturbance

Human presence was recorded at 11 out of 73 observation stations, namely sub-grid stations 36.3a and 36.15. a, 36.16, 37.8, 37.18, 37.19, 54.12, 54.14, 40.5, 40.14, and station 40.15B as shown in Figure 6. a, and station data that



(a)

recorded human activities in 2017-2022 as shown in Figure 6. b.



(b)

Figure 6. Potential human disturbance: (a) human presence in 2022, (b) human presence in 2017-2022

The data review revealed that the presence of humans had no discernible impact on the animal data captured by video traps. However, human activities that enter the area illegally can harm the area and the people themselves. People who hunt can reduce populations and biodiversity. A decrease in the population of prey animals such as deer, antelope, wild boar, long-tailed monkeys, and langurs has the potential to disrupt the survival habitat of the Javan leopard. In addition, as it is known that the Javan leopard is active during the day and night, there is a possibility of the Javan leopard meeting with humans, which has the potential to cause conflict (Partasmita *et al.*, 2016; Consolee *et al.*, 2020; Viollaz *et al.*, 2021; Badhe & Jaybhaye, 2024; Burgos *et al.*, 2024; Daud *et al.*, 2024; Mishra *et al.*, 2024).

Our results suggest that the Java Leopard population is increasing. The increasing Java Leopard population is supported by stable environmental conditions, availability of prey animals, and minor disturbance to animals and their habitat. These conditions support the regeneration of this animal and reinforced by the video footage of a female Javan leopard suspected to be still nursing her cubs (visible from her nipples as if she was still breastfeeding) and video footage of young individuals as an indication of regeneration in the population (Woodroffe & Ginsberg, 2000; Traylor-

Holzer *et al.*, 2020; JET *et al.*, 2024; Zaman *et al.*, 2024).

Conclusions

This preliminary study recorded six individuals of Java Leopard in Meru Betiri National Park, with five categories and nine behavior activities. The categories of activities were walking, observing, standing, cheek rubbing, scraping, urine spraying, claw marking, parenting, and vocalizing. The nine types of behavior were moving, resting, marking, socializing, and miscellaneous. The most frequent behavior that took the most time was moving.

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