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ASSESSING THE IMPACT OF MULTI-MODAL ENRICHMENT ON BEHAVIORAL DIVERSITY AND WELFARE INDICATORS IN CAPTIVE MALAYAN SUN BEARS *(HELARCTOS MALAYANUS)*

By

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ABSTRACT

The Malayan sun bear *(Helarctos malayanus),* the smallest member of the Ursidae family, faces significant welfare challenges in captivity, where restricted environments often result in stress and the development of stereotypic behaviours. This study investigates the impact of multi-modal enrichment comprising food-based, sensory, structural, cognitive, and auditory interventions on the behavioural diversity and welfare indicators of captive Malayan sun bears. Conducted over 21 days at the National Wildlife Rescue Centre (NWRC), Sungkai, Perak, two adult sun bears were observed using a within-subject experimental design, with behaviours recorded through focal sampling and scan sampling at 1-minute intervals for 30-minute sessions during morning and afternoon periods. Behavioural categories assessed included exploratory activity, feeding, play, resting, novelty response, avoidance, stress indicators, agonistic displays, and stereotypy. The findings revealed clear individual differences: Awe Jerek frequently exhibited stress-related and agonistic behaviours**,** especially during baseline while Mek Bantal displayed distinct stereotypic pacing, moving back and forth repetitively**,** particularly during non-enrichment periods. Implementation of food-based, structural, sensory, and cognitive enrichment increased exploratory behaviour and reduced the duration of stereotypies in both individuals, whereas auditory enrichment promoted calmness but showed variable effectiveness. Overall, multi-modal enrichment improved behavioural diversity and reduced indicators of compromised welfare, demonstrating its value in enhancing the management and ex-situ conservation of captive Malayan sun bears.

Keywords: *Malayan sun bear, enrichment, behavioural diversity, wildlife captive welfare.*

ABSTRAK

Beruang matahari Malaysia *(Helarctos malayanus)*, spesies beruang terkecil di dunia, menghadapi cabaran kebajikan yang ketara dalam kurungan, di mana persekitaran yang terhad sering menyebabkan tekanan dan perkembangan tingkah laku stereotaip. Kajian ini menilai kesan pengayaan multi-modal merangkumi pengayaan berasaskan makanan, deria, struktur, kognitif dan auditori terhadap kepelbagaian tingkah laku dan petunjuk kebajikan beruang matahari dalam kurungan. Kajian dijalankan selama 21 hari di Pusat Penyelamat Hidupan Liar Kebangsaan (NWRC), Sungkai, Perak, melibatkan dua ekor beruang dewasa yang diperhati menggunakan reka bentuk dalam subjek, dengan tingkah laku direkod melalui pensampelan fokus dan scan sampling pada selang 1 minit bagi setiap sesi 30 minit pada waktu pagi dan petang. Kategori tingkah laku yang dinilai merangkumi eksplorasi, makan, bermain, rehat, tindak balas novel, pengelakan, stres, tingkah laku agonistik dan stereotaip.Dapatan menunjukkan perbezaan individu yang ketara: Awe Jerek kerap mempamerkan tingkah laku stres dan agonistik**,** terutamanya semasa fasa awal pengayaan, manakala Mek Bantal menunjukkan tingkah laku stereotaip pergerakan berjalan ulang-alik secara berterusan**,** terutamanya dalam fasa tanpa pengayaan. Pelaksanaan pengayaan makanan, struktur, deria dan kognitif meningkatkan tingkah laku eksplorasi dan mengurangkan tempoh tingkah laku stereotaip bagi kedua-dua individu, manakala pengayaan auditori menggalakkan ketenangan tetapi menunjukkan keberkesanan yang berubah-ubah. Secara keseluruhan, pengayaan multi-modal meningkatkan kepelbagaian tingkah laku dan mengurangkan penunjuk kebajikan yang terjejas, sekali gus menunjukkan kepentingannya dalam meningkatkan pengurusan dan usaha konservasi ex-situ bagi beruang matahari Malaysia.

Kata Kunci: *Beruang matahari Malaysia, pengayaan tingkah laku tekanan kepelbagaian, kebajikan hidupan liar dalam kurungan.*

CERTIFICATIONS

This is to certify that we have read this research paper **entitled 'Assessing The Impact Of Multi-Modal Enrichment On Behavioral Diversity And Welfare Indicators In Captive Malayan sun bears *(Helarctos Malayanus)*'** by **Dilashinee Chelladurai**, and in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirements for the course DVT 55204 - Research Project.

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Family

Lycan (XIII)

Thank You

DEDICATIONS

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LIST OF ABBREVIATIONS

NWRC – National Wildlife Rescue Centre

IUCN - International Union for Conservation of Nature

ARB – Abnormal Repetitive Behaviour

DWNP – Department of Wildlife and National Parks Peninsular Malaysia

ACUC PTj - Animal Care and Use Committee, Pusat Tanggungjawab (UMK)

MIN – Minute

ID - Identification / Animal ID

Kg – Kilogram

PVC – Polyvinyl Chloride

IBM SPSS - International Business Machines – Statistical Package for the Social Sciences

SD – Standard Deviation

AM – Ante Meridiem (Morning Session)

PM – Post Meridiem (Afternoon Session)

H1 – Hypothesis 1

H2 – Hypothesis 2

H3 – Hypothesis 3

n – Sample size

Enr – enrichment

A - avoidance

AG - agnostic

E - exploratory

F - foraging

N - novelty

RT - resting

SS - stress

ST -Stereotypic

V - vocalization

LIST OF SYMBOLS

% - Percentage

± - Plus-minus (used with SD)

< - Lesser than

> - Greater than

CHAPTER 1
INTRODUCTION

1.1 Research Background

The sun bear *(Helarctos malayanus),* recognized as the smallest extant member of the Ursidae family, represents a remarkable example of tropical adaptation among bear species. Endemic to the Southeast Asian rainforests, this arboreal omnivore exhibits unique morphological adaptations including a distinctive golden chest patch, commonly called the "sun" marking, an exceptionally long tongue up to 25 cm, and powerful curved claws due to the all- evolutionary solutions for its specialized honey and insect-based diet (Lariviere et al., 2025).As a keystone species, sun bears play a critical role in maintaining forest ecosystems through seed dispersal and creating microhabitats via their foraging activities (Hays, 2025).

The species' conservation status, currently listed as Vulnerable by IUCN, reflects multiple anthropogenic threats, including rapid habitat loss from palm oil plantations, which is estimated at a 30-49% population decline over 30 years and intense poaching pressure for the traditional medicine trade (Hays, 2025).In captive environments, sun bears present particular welfare challenges due to their high cognitive capacity and complex natural behaviours. As a species classified as Vulnerable by the IUCN, the demonstrated ability of multidimensional enrichment programs incorporating arboreal structures, food-based cognitive puzzles, and olfactory stimulation to reduce stereotypic behaviours by up to 80% underscores the urgent need for effective enrichment to support welfare, behavioural competence, and conservation outcomes in captive populations. These findings underscore the necessity for ex-situ conservation programs to implement evidence-based, species-appropriate management protocols that address both physiological and psychological needs (PM, KTH and KL, 2015).

1.2 Research Problem Statement

Despite the established importance of environmental enrichment in captive animal welfare, significant gaps remain in understanding its optimal application for sun bears *(Helarctos malayanus)*. Current research on this vulnerable species has primarily examined singular enrichment modalities, neglecting the potential synergistic benefits of integrated, multi-modal approaches that may better address their complex cognitive and ecological needs (Clark, 2017). This limitation is particularly concerning given sun bears demonstrated susceptibility to stereotypic behaviours in captivity (Wong, 2021).

This study will address these critical knowledge gaps through a systematic behavioural assessment of two captive Malayan sun bears at National Wildlife Rescue Centre. The efficacy of isolated versus combined enrichment types (food-based, sensory, and structural) will be compared in promoting species-typical behaviours documented in wild populations. The animal's responses and changes in behavioural diversity to the enrichment types will be quantified using established ethograms. The insights of this study can be used to create evidence-based enrichment procedures customized to sun bears' distinct arboreal and foraging specializations. Furthermore, the findings will give critical data for improving ex-situ conservation efforts for this imperiled species, as well as contribute to theoretical frameworks for enrichment in behaviourally complex mammals.

1.3 Research Question

1. How do different environmental enrichment strategies (food-based, sensory, structural, cognitive, and music-based) influence the behavioural responses and welfare of captive Malayan sun bears (Helarctos malayanus)?
2. To what extent do behavioural changes elicited by environmental enrichment reduce stereotypic behaviours and enhance species-typical behaviours, thereby improving the overall welfare of captive Malayan sun bears?

1.4 Research Hypothesis

- H1: Environmental enrichment interventions will lead to a significant increase in species-typical behaviors (such as foraging, exploration, and play) and a reduction in stereotypic behaviors (such as pacing) in captive Malayan sun bears.
- H2: Different types of enrichment (food-based, sensory, structural, cognitive, and music-based) will have distinct effects on captive Malayan sun bear behavior, with food-based and structural enrichment having the most pronounced positive impact on reducing stereotypic behaviors and enhancing natural behaviors.
- H3: Auditory enrichment (such as music or nature sounds) will reduce stress-related behaviors and improve overall welfare in captive Malayan sun bears.

1.5 Research Objectives

- To observe and evaluate the behavioural responses of captive Malayan sun bears to various environmental enrichment strategies (food-based, sensory, structural, cognitive, and music-based).
- To assess the impact of these enrichment strategies on the reduction of stereotypic behaviors and enhancement of species-typical behaviors, thereby improving the overall welfare of captive Malayan sun bears.

CHAPTER 2
LITERATURE REVIEW

2.1 Stereotypic Behaviour in Captivity

Captive carnivores, particularly members of the Ursidae family, commonly develop abnormal repetitive behaviours (ARBs) such as pacing, overgrooming, bar-biting, and somersaulting when maintained in environments that do not meet their behavioural or psychological needs (Mason, 2010). These behaviours are widely interpreted as indicators of chronic stress, frustration, or the inability to perform highly motivated natural behaviours such as foraging, climbing, and extensive ranging. Inadequate enclosure size, barren or monotonous habitats, limited opportunities for sensory stimulation, and restricted control over the environment are among the most influential factors contributing to ARB development (Mason, 2010).

Sun bears *(Helarctos malayanus)*, the smallest and most arboreal bear species, are especially vulnerable to the effects of environmental deprivation. In the wild, they spend significant time climbing, foraging for insects and fruits, tearing apart logs, and exploring large home ranges (International Association for Bear Research and Management, 2024). When these complex, species-specific behaviours cannot be expressed in captivity, sun bears frequently exhibit stress-related actions, with pacing, excessive claw- licking, snout-licking, and repetitive sitting or standing postures being the most documented stereotypies (Abdul-Mawah et al., 2022). Previous studies have shown that these behaviours intensify in enclosures with insufficient vertical space, low structural complexity, or a lack of enrichment that mimics natural foraging challenges. The prevalence of these repetitive behaviours highlights the strong relationship between enclosure quality and psychological well-being in captive Malayan sun bears (Tan et al., 2012).

While the physical needs of animals such as food and shelter are typically met in captivity, the conditions of confinement and exposure to humans can result in physiological stress. The stress response consists of a suite of hormonal and physiological reactions designed to help an animal survives potentially harmful stimuli. Although these responses are adaptive in the short term, chronic activation of stress can lead to negative physiological outcomes, including weight loss, immunosuppression, and reduced reproductive capacity (Fischer & Romero, 2019b). Many caretakers assume that wild animals will eventually adjust to captivity however, prolonged

exposure to stressors, such as cage restraint, human presence, unfamiliar surroundings, and subtle factors like artificial lighting, can have lasting or even permanent effects on physiology. These stressors can prevent animals from returning to a baseline state, leading to chronic stress symptoms that may exacerbate stereotypic behaviours and compromise overall welfare (Fischer & Romero, 2019).

Overall, stereotypic behaviours and physiological stress in captivity serve as crucial indicators of animal welfare. They underscore the need for carefully designed enclosures, consistent and species-appropriate enrichment, and management practices that allow natural behaviours to be expressed while minimizing chronic stress.

2.1 Enrichment Benefits

Environmental enrichment is widely recognized as a critical component of improving welfare in captive animals (Kristine Coleman, 2017). Well-designed enrichment programs aim to provide stimuli that promote natural behaviours, mental engagement, and physical activity, thereby reducing the negative impacts of confinement.

Meta-analyses show that well-designed enrichment programs greatly increase captive animal welfare by enhancing behavioural variation and lowering physiological stress markers (Clark, 2017). These changes correlate with improved body condition scores and reproductive success in captive populations (Caro, 2016). For sun bears, enrichment interventions such as manipulable objects, foraging devices, climbing structures, and sensory stimuli allow expression of natural behaviours that are otherwise restricted in captivity. Research shows that enrichment can reduce stereotypic behaviours such as pacing and excessive claw-licking, while encouraging exploration and foraging behaviours similar to those observed in the wild (Mason, 2010). This demonstrates that enrichment not only addresses behavioural welfare but also supports physiological well-being.

One of the most widely cited definitions of enrichment in zoo management describes it as "an animal husbandry principle that seeks to enhance the quality of captive animal care by identifying and providing the environmental stimuli necessary for optimal psychological and physiological well-being" (Shepherdson, 1998). This definition emphasizes that enrichment should actively improve welfare, rather than simply occupying animals. Despite this, many enrichment studies focus narrowly on behaviour frequency, overlooking broader physiological and psychological outcomes (Young, 2013).

2.2 Cognitive Enrichment

As highly intelligent omnivores, sun bears benefit particularly from cognitive challenges that simulate natural foraging. Puzzle feeders requiring sequential problem-solving, for example, rotating cylinders with hidden food compartments, have been shown to increase active engagement time from < 2 to > 6 hours daily, reduce stereotypic behaviours by 55% and promote species-typical forelimb dexterity (Ghavamian et al., 2022).

In the wild, animals face a variety of challenges related to locating food, securing mates and shelter, and avoiding predators (Shettleworth, 2010). These ecological pressures necessitate a range of cognitive skills, including exploration, problem-solving, various forms of learning, and spatial awareness. The cognitive skills an animal exhibits depend on both the challenges it currently encounters and its evolutionary history (Meehan & Mench, 2007). Importantly, animals are initiative-taking to explore and acquire resources even when these resources are readily available without cognitive or physical effort (Wemelsfelder & Birke, 1997; Wood-Gush & Vestergaard, 1991).

Puzzle feeders typically conceal food within boxes, pipes, or balls, requiring the animal to poke, shake, or rotate these objects before food is released under the force of gravity (Bloomstrand, Riddle, Alford, & Maple, 1986). These devices make food acquisition more challenging than routine feeding, thereby increasing engagement, reducing time spent on abnormal behaviours, and promoting activity that mirrors natural foraging (Brent & Eichberg, 1991).

2.3 Sensory Enrichment

Sun bears have evolved exceptional sensory capabilities to navigate the complex rainforest habitats they naturally occupy. In the wild, they rely heavily on acute olfactory, tactile, and visual cues to locate food, detect predators, and explore their environment. Captive environments that fail to provide sufficient sensory stimulation can result in behavioural impoverishment. Research indicates that barren enclosures are associated with 40–60% of daily activity budgets being occupied by stereotypic pacing in sun bears (Wong, 2021), highlighting the critical role of sensory input in promoting normal behaviour.

Sensory enrichment aims to engage multiple modalities, including tactile, auditory, visual, olfactory, and gustatory senses. While olfaction and taste are often incorporated into feeding-based enrichment strategies, tactile, visual, and auditory stimuli can be delivered independently to encourage exploration and cognitive engagement. For instance, trees and

complex climbing structures in enclosures provide varied textures for scratching, diverse scents from natural substrates, and visual complexity through elevated platforms and branches. Such arrangements simultaneously stimulate multiple senses, promoting natural behaviours and reducing the occurrence of stereotypic behaviours (Barnes, 2022).

By catering to the sensory needs of sun bears, enrichment programs can more closely replicate the challenges and stimuli experienced in the wild, supporting both psychological and physiological well-being. Incorporating a variety of sensory experiences ensures that animals remain engaged, curious, and active, ultimately enhancing overall welfare in captivity.

2.4 Structural Enrichment

Structural enrichment plays a crucial role in promoting natural behaviours and improving welfare in captive Malayan sun bears *(Helarctos malayanus).* A study by (Izzat Husna et al., 2021) observed that sun bears in a rehabilitation center displayed fewer stereotypic behaviours and more species-typical activities, such as climbing and foraging, when provided with enriched environments that mimicked their natural habitat. Structural enrichment components such as climbing platforms, logs, and a variety of substrates increased physical activity while decreasing stress-related behaviours, emphasizing the role of enclosure complexity in improving psychological well-being.

Although structural enrichment can substantially enhance the complexity of captive environments (Maple & Perkins, 1996), it is often underutilized compared to feeding-based enrichment in many zoos (Schetini de Azevedo et al., 2007). Many carnivore species are highly exploratory, and activities such as foraging, territorial marking, social interaction, and play can occupy a significant portion of their daily time budgets (Poole, 1992). Enclosures must therefore be designed to accommodate these ecological and behavioural needs, ensuring animal welfare (Hughes & Duncan, 1988; Broom, 2007).

Previous studies in related bear species provide additional support for structural enrichment. For example, in spectacled bears *(Tremarctos ornatus),* the addition of climbing structures reduced pacing and motionless sitting while increasing overall activity, demonstrating that structural enrichment can effectively reduce abnormal behaviours and promote naturalistic behaviours. These findings underscore the importance of implementing structural complexity in captive sun bear management to support both physical and psychological well-being

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Ethical approval

This study was conducted with the necessary consent and permits from the Department of Wildlife and National Parks Peninsular Malaysia (DWNP). The permit was granted with registered number of **A-00343-15-25** to ensure that the research adhered to ethical standards for the welfare of the captive sun bear and to support the conservation efforts for this critically endangered subspecies. All enrichment interventions aligned with the guidelines for ethical animal care and approval by the Chairperson, Animal Ethics Committee of the Faculties/Centres (ACUC PTj), Universiti Malaysia Kelantan (UMK) with the approval number is **UMK/FPV/ACUE/FYP/023/2025**

3.2 Study area

The study was conducted at the National Wildlife Rescue Centre (NWRC) in Sungkai, Perak, Malaysia, with a focus on both male and female sun bears *(Helarctos malayanus)*. The NWRC plays a critical role in the ex-situ conservation of endangered wildlife and is recognized for its efforts in rehabilitating and preserving species such as the sun bear. The center is strategically located within the Sungkai Wildlife Reserve, providing a controlled yet naturalistic environment that is well- suited for the observation of wildlife behaviour.

The NWRC functions as a major conservation hub, supporting a variety of programs including captive breeding, wildlife research, and educational outreach. For this study, behavioural observations were conducted in enclosures specifically designed for sun bears. The subjects were housed within a large building dedicated to sun bears *(Helarctos Malayanus),* accommodating a total of five individuals. These enclosures provide a combination of shelter, climbing structures, and other enrichment features, allowing researchers to assess the effects of multimodal enrichment on sun bear behaviour.

The NWRC's offers an ideal setting for this research, enabling observations in controlled environments while allowing for naturalistic behavioural expression. Studying sun bear behaviour in this context provides valuable insights into how different types of enrichment can reduce stereotypic behaviours, enhance activity levels, and improve overall well-being in captive settings.

3.1 Study design

An experimental within-subject design with ethogram-based behavioural observation was employed, where each sun bear served as its own control. Behavioural observations were carried out across different enrichment types over a period of three consecutive weeks.

The enrichment types selected in this study control (no enrichment), food-based & sensory, structural & cognitive, and auditory (music/nature sounds) represent different dimensions of environmental enrichment commonly used to stimulate natural behaviours and improve welfare in captive sun bears. The control and post-test (no enrichment) phases were included to establish baseline behaviour and assess whether any behavioural changes persisted after enrichment removal. While most current research has focused on singular enrichment modalities, this study explores the potential benefits of combining multiple enrichment types to enhance behavioural outcomes and overall welfare. The study was conducted over a 21-day period due to time constraints, which was considered sufficient to observe short-term behavioural responses and welfare-related changes.

The enrichment types selected, Food-Based & Sensory, Structural & Cognitive, and Auditory (music/nature sounds), were chosen because a study conducted by (Bashaw et al., 2003)noted that providing sun bears with scent trails, scatter feeds and food hidden inside objects led to an increase in foraging and exploratory behavior and a reduction in the display of stereotypic behaviours. The Control and Post-test (no enrichment) phases were included to establish baseline behaviour and assess whether any behavioural changes persisted after enrichment removal. The study was conducted over a 21-day period due to time constraints but based on my observation it is enough to notice short-term behavioural responses and welfare-related changes.

Behavioural observations were conducted using a combination of focal animal sampling and scan sampling at 1-minute intervals for 30 min session Observations were carried out during two daily time blocks: Morning (9.00 a.m. – 11.30 a.m.) and Afternoon (2.00 p.m.– 4.30 p.m.), ensuring coverage of active periods in the sun bears' daily routine. Each bear was observed

individually for 5-minute periods, alternating between male and female subjects. A stopwatch was used to maintain precise timing, and an ethogram-based observation sheet was employed to record all behaviours systematically.

Observations were performed from outside the enclosures at a fixed vantage point to minimize disturbance. Camera traps and a handheld digital camcorder were used to facilitate detailed monitoring and to allow for video-based verification of behavioural records. This combination of focal and scan sampling allowed for the collection of both individual-specific behaviours and overall activity patterns, providing a comprehensive assessment of the effects of multimodal enrichment on sun bear behaviour.

Table 3.3.1 Ethogram chart of behavioural acts in the Sun Bear

Behavioural Acts	Description	Remarks
Exploratory	Sniffing, digging, pawing, climbing	
Feeding	Eating, licking, foraging	
Resting	Sleeping, sitting idly, lying	
Play	Object manipulation, pacing with interaction, running, climbing.	
Novelty	Latency to approach, first interaction with enrichment	
Avoidance	Retreating from enrichment, hesitation	
Stereotypic	Pacing, head bobbing, paw sucking	
Stress	Hiding/ Withdrawal, self-directed behaviours (paw-sucking)	
Agonistic	Growling, Bar striking, charging	
Others		

Table 3.3.2 Focal sampling worksheet of behaviours in male Sun Bear

(Helarctos Malayanus)

Animal ID: Sex: Date: Start time: End time:

Time (MIN)	Exploratory	Feeding	Stress	Agonistic	Novelty	Avoidance	Resting	Remarks

Table 3.3.3 Focal sampling worksheet of behaviours in female Sun Bear *(Helarctos Malayanus)*

Animal ID: Sex: Date: Start time: End time:

Time (MIN)	Exploratory	Feeding	Stereotypic	Vocalization	Novelty	Avoidance	Resting	Remarks

3.1 Study population

The study involved two adult sun bears *(Helarctos malayanus),* one male and one female, housed at National Wildlife Rescue Centre (NWRC) in Perak, Malaysia. Selection of these individuals was based on their availability, overall health, and suitability for behavioural observation during the study period. Purposive sampling was employed to ensure that the chosen bears met specific behavioural, health, and management-related criteria.

It is important to note that individual differences in behavioural responses were observed between the two subjects. Awe Jerek exhibited primarily stress-related and agonistic behaviours, whereas Mek Bantal displayed stereotypic behaviours as the predominant concern. This difference does not undermine the study but reflects the natural variation in how individual sun bears respond to captivity and enrichment interventions. To account for this, behavioural observations were tailored to the initial baseline behaviours of each individual. For Awe Jerek, the focus was on monitoring stress and agonistic behaviours, while for Mek Bantal, the focus was on stereotypic behaviours. Both individuals were subsequently exposed to the same multi-modal enrichment interventions, allowing for evaluation of behavioural changes relative to their baseline. This approach ensures that the methodology remains consistent in its objective to assess the impact of enrichment on reducing undesirable behaviours—even if the specific behavioural parameters measured differ due to individual variation.

Inclusion criteria required that the bears were of the Malayan sun bear species, sexually mature adults estimated to be between 6 and 10 years of age, and clinically healthy as verified by NWRC veterinary staff. Individuals showing no visible injuries, abnormal behaviours, or ongoing treatments were considered suitable for participation. The selected bears were individually housed in adjacent enclosures, allowing for visual and olfactory contact but preventing direct physical interaction.

They were accustomed to human presence, calm during observation, and not scheduled for relocation, medical procedures, or breeding introductions during the three-week study period (21 days). Exclusion criteria eliminated bears with chronic health conditions, those undergoing veterinary treatment, individuals exhibiting extreme stress or fear during baseline observations, and those engaged in

reproductive activity or nursing. Bears that had participated in behavioural or enrichment studies within the past two months, or had been temporarily removed from enclosures, were also excluded to avoid confounding factors

Individual profiles, including sex, age, feeding schedule, housing condition, and prior enrichment exposure, were documented on Day 0 (Pre-study baseline).

Table 3.4.1: Study population data

ID	Sex	Age (Year)	Weight (kg)	Date Of Acquisition	Origin	Unit of Night Stall
Awe Jerek	Male	+/- 15	75	23.10.2024	Jerek, Gua Musang	2
Mek Bantal	Female	+/- 1.5	35	3.1.2025	Kg. Bantal Jerantut	2

3.1 Sampling techniques

A purposive, within-subject sampling design was applied. Both bears experienced all enrichment types and served as their own control, allowing intra-individual behavioural comparisons across conditions. Observation Schedule: The study consisted of a 21-day structured observation cycle, divided into 4 experimental phases:

Table 3.5.1: Observation schedule for 21 days which is divided into 4 experimental phases.

DAYS	PHASE	ENRICHMENT TYPE	OBJECTIVE
1-3	1	Control (No enrichment)	Establish baseline behaviours (exploratory, stereotypic, resting, play, feeding and avoidance
4-9	2	Food-Based & Sensory	Stimulate foraging, reduce boredom, encourage olfactory. response
10-15	3	Structural & Cognitive	Promote natural climbing/digging and problem-Solving
16-20	4	Auditory (Music/Nature Sounds)	Promote relaxation, reduce pacing and stress behaviours
21	5	No enrichment (Post-test)	Compare retention. vs. baseline

Outline enrichment interventions implemented during phases.

- **Phase 2**

During Days 4 and 5, Seasonal Fruits Scattered together with a Pandan Leaf Trail were introduced to stimulate natural foraging and enhance olfactory exploration. Seasonal fruits such as papaya, banana, jackfruit, and mango were cut into medium-sized chunks and scattered unevenly across the enclosure floor, especially in corners, behind logs, and near vegetation to promote active searching. Dried pandan leaves were shredded, lightly crushed to release their scent, and arranged in a meandering line across the enclosure floor or enrichment zones. Fruits were placed early each morning before the observation period, and latency to approach as well as duration of foraging behaviour were recorded. To ensure safety, only fresh, pesticide-free fruits were used, and overfeeding was avoided. This enrichment aimed to stimulate feeding, exploratory behaviour, novelty response, playfulness, and to observe any avoidance reactions.

Figure 3.5.1: This designed trail pathway uses the pandan leaves, nuts and fruits.

Figure 3.5.2: This ***is the fruits that has been tied together with pandan leaves to make the trail pathway.***

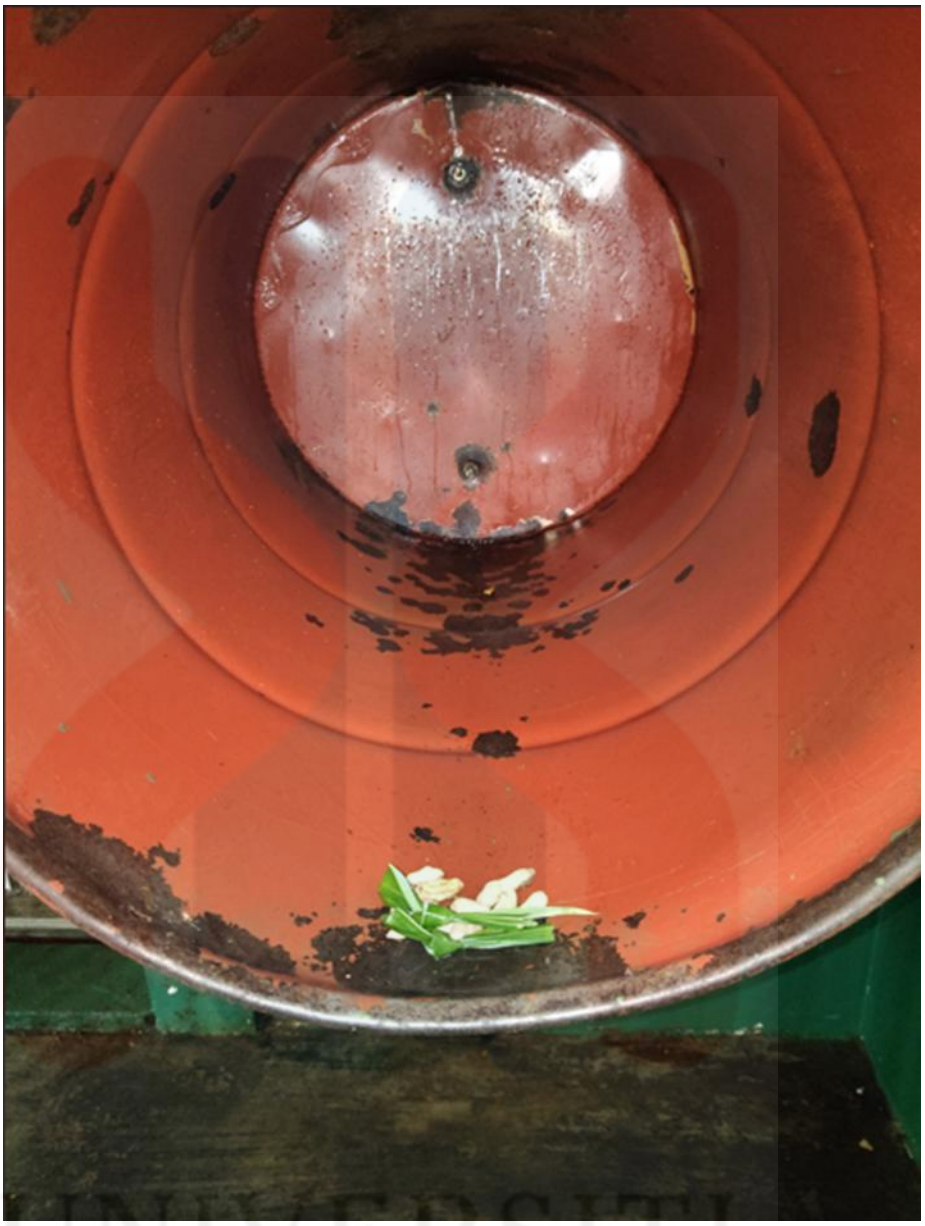

Figure 3.5.3: The placement of pandan leaves inside the barrel with nuts.

On Days 6 and 7, Puzzle Feeders filled with fruits were implemented to encourage problem-solving and reduce boredom. Wooden puzzle feeders with different patterns were inspected for sharp edges before use. Small fruit pieces were smashing and spreading on the wooden puzzle feeders inside the feeders, ensuring a moderate level of challenge. The feeders were then put on the floor of the night stall in accessible parts of the enclosure. Bears' interactions were closely monitored, and minimal assistance was provided only if they struggled for more than five minutes. Feeders were cleaned regularly with soap and water to prevent mold or bacterial growth. This enrichment focused on stimulating feeding motivation, cognitive engagement, manipulation behaviour, and identifying signs of problem-solving or frustration.

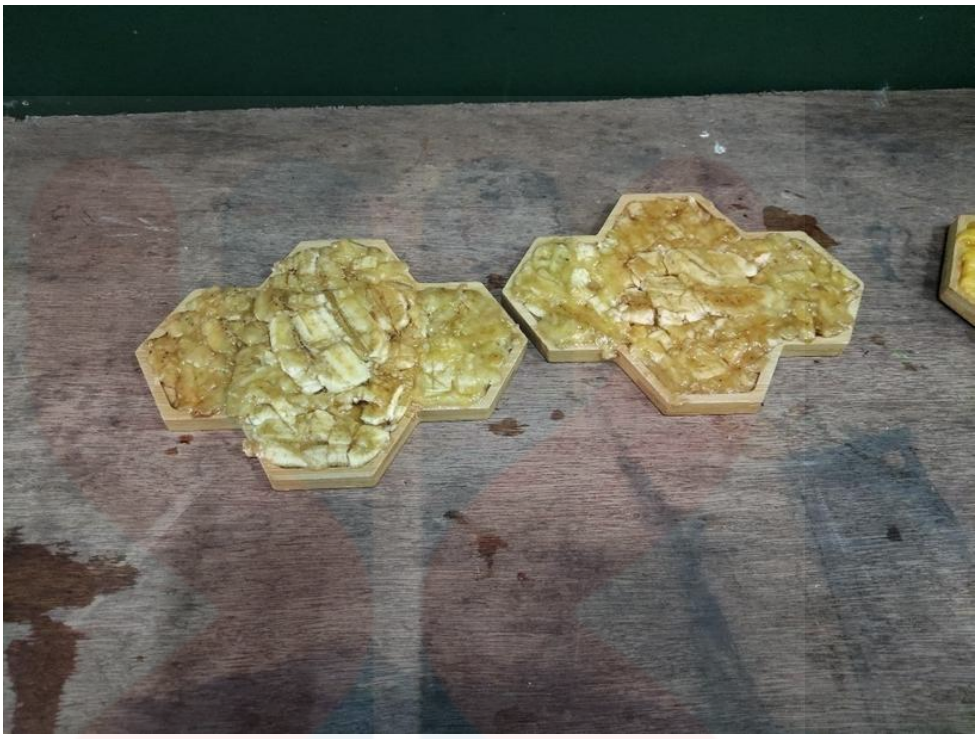

Figure 3.5.4: This is the feed puzzle that was used for sensory enrichment where the fruits were smashed and spread on the plate.

During Days 8 and 9, Ice Treats with Hidden Fruit were paired with lemongrass-scented items to provide cooling enrichment and sensory stimulation. Ice cube trays were filled with water mixed with honey and cut fruit pieces were added before freezing overnight to create long-lasting ice blocks. The next morning, the ice treats were put inside the puzzle feeders constructed from PVC tubes. These ice treats prolonged feeding time and encourages both physical manipulation and cognitive engagement as the bears worked to access the embedded fruits. Lemongrass was placed inside a barrel along with leftover fruit pieces to stimulate olfactory exploration and observe interactions such as sniffing, biting, and manipulation. This combination created a multi-sensory experience that supported thermoregulation, especially when provided on warm days or during afternoon sessions, while also promoting curiosity, exploratory behaviour, and reduced inactivity during hot periods. Behaviour was monitored closely, focusing on responses such as licking, sniffing, manipulation, and overall interest toward the enrichment items.

Figure 3.5.5: These are the hidden fruits inside the ice cube for sensory enrichment.

Figure 3.5.6: This is the hidden fruits inside the ice cube that are put inside the puzzle

feeder for both sun bears.

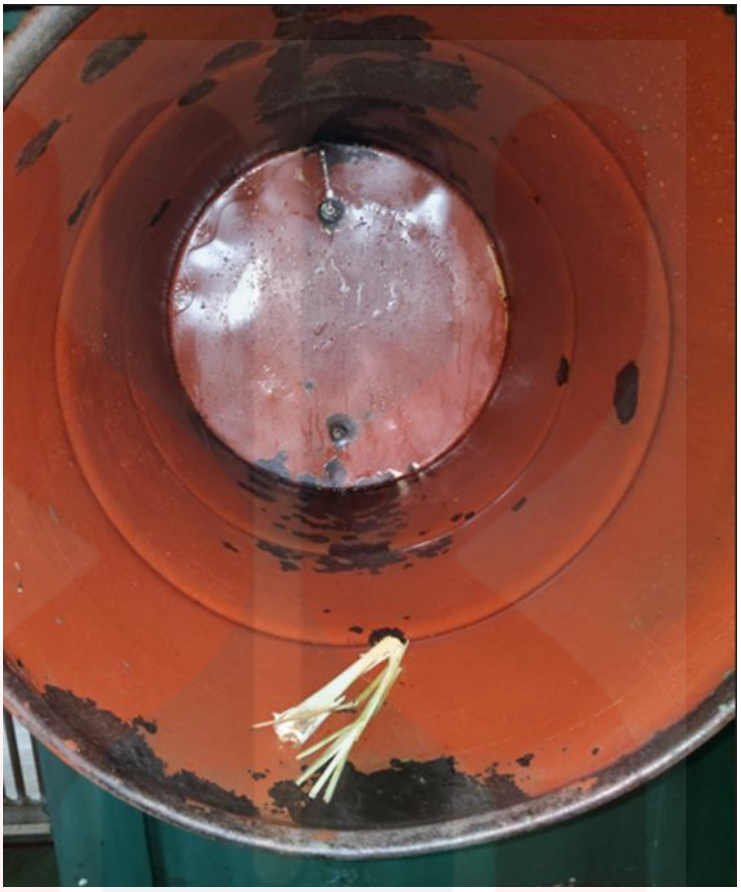

Figure 3.5.7: Presence of the lemongrass inside the blue barrel for Awe Jerek

- **Phase 3**

During Days 10 and 11, Tire Swings Hanging were introduced to promote climbing behaviour and increase physical exercise. Well-cleaned tires were prepared using durable ropes and attached to secure points within the enclosure. Prior to installation, all materials were inspected to ensure they were free from debris, splinters, or structural risks. The tire was hung in the middle of the night stall. Then the fruits will be filled inside the tire to encourage diverse climbing patterns and stimulate upper-body activity. Daily checks were carried out to monitor wear and tear and ensure ongoing safety. Throughout the session, behavioural observations focused on climbing attempts, swinging, and overall interaction with the suspended items, providing insight into the bear's physical engagement, confidence, and environmental use.

Figure 3.5.8: The cut fruits were put in the modified tire for the structural enrichment .

On Days 12 and 13, Platform Feeding Stations paired with Manipulation Logs were introduced to encourage forelimb use, problem-solving, and natural foraging behaviours. Raised wooden platforms were set up in accessible areas of the enclosure, while logs containing natural cracks or drilled holes were filled with small fruit pieces or nuts to create a simple puzzle-like challenge. Fruits were also put in different areas or at the corner of the night stall for them to find and the fruits were also put inside the drinking pool to let them play with water and foraging. Bears were guided toward the platforms during feeding sessions, where researchers observed behaviours such as pawing, digging at the logs, manipulation of holes, and attempts to retrieve hidden food items. This enrichment supported climbing, feeding, and interaction

while also aiming to reduce stereotypic behaviours by shifting focus toward cognitively engaging tasks.

Figure 3.5.9: This picture shows the placement of the fruits with pandan or lemongrass at the stairs to the wooden platform and there is also the presence of hanging tires for structural enrichment.

Figure 3.5.1: showing the placement of fruits inside the log.

During Days 14 and 15, Dig Pits combined with puzzle-based materials were implemented to simulate natural digging behaviour and introduce cognitive challenge. Banana leaves were used to wrap and hide fruit pieces, mimicking wild foraging substrates that require manipulation and investigation. In addition, coconuts were placed inside the drinking pool to encourage interaction, retrieval attempts, and problem-solving through water-based exploration. Treats were also scattered within the soil pits to motivate the bears to dig, search, and uncover hidden rewards. Behavioural observations focused on digging intensity, manipulation of the banana-leaf bundles and coconuts, exploratory actions, and indicators of frustration or persistence. This enrichment aimed to strengthen natural foraging instincts while providing meaningful mental stimulation through goal-directed tasks.

Figure 3.5.11: The fruits were put on the floor of night of Awe Jerek and hidden inside the banana leaves for dig pit enrichment.

- **Phase 4**

During Days 16 and 17, Jungle Ambience audio was introduced to promote relaxation and reduce stress. Portable waterproof speakers were used to play high-quality recordings of jungle birds, streams, and rain, specifically the "10 Common Backyard Bird Songs of the Eastern US" by Navarre's Wild Shots. The volume was tested beforehand to ensure the sound was audible yet not startling, and playlists were set to loop continuously for 30–60 minutes. Audio was played during resting periods or throughout the enrichment session, and behavioural observations focused on changes in pacing, resting posture, and overall alertness to assess the calming effects of natural acoustic stimuli.

On Days 18 and 19, Rainforest and Flute Instrumental Tracks were used to enhance calmness and stimulate curiosity. The setup mirrored the jungle ambience method, but with recordings that blended soft flute music with natural sounds, including gentle rain hitting clay jars, distant thunder, rainforest ambience, and bird calls. These tracks were alternated with the jungle sounds from previous sessions to prevent habituation and maintain novelty. Observations concentrated on subtle behavioural indicators of calmness, such as reduced pacing, slow head movements, exploratory sniffing, and periods of stillness, allowing assessment of the bears' responses to

more melodic and layered acoustic enrichment.

On Day 20, A combined enrichment session was conducted by pairing nature sound playback with food-based enrichment to provide multimodal stimulation. Audio tracks featuring a mixture of animal sounds—such as elephant, tiger, leopard, sun bear, eagle, and various birds—were played while food items were simultaneously introduced into the enclosure. This combination aimed to create a more dynamic sensory experience by merging auditory novelty with feeding motivation. Behavioural observations focused on how the bears modulated their interaction with the food items in the presence of sound, including signs of increased curiosity, reduced pacing, and the overall synergy between feeding engagement and acoustic stimulation.

3.2 Data collection tools

Behavioural observations were conducted using predefined ethograms on structured observation sheets to ensure systematic recording of sun bear behaviours. Detailed behavioural sequences were captured using audio-video recordings with a digital camcorder, allowing for subsequent review and analysis. Precise timing of behaviours was maintained with a stopwatch and wristwatch, enabling accurate sampling during focal and scan observation sessions.

Various forms of enrichment were employed to stimulate natural behaviours and enhance overall welfare. Food-based enrichment included seasonal fruits such as papaya, banana, and jackfruit, as well as ice treats containing hidden fruit pieces, designed to encourage natural foraging and feeding behaviours. Cognitive enrichment was provided through puzzle feeders constructed from PVC tubes and food cubes with movable parts, promoting problem-solving skills and forelimb manipulation. Sensory enrichment incorporated natural aromatic components, including dried herbs, pandan leaves, and lemongrass, to engage olfactory and gustatory senses.

To promote physical activity and natural exploration, structural enrichment features such as tire swings, climbing ropes, hanging logs, wooden tunnels, and hideouts were provided. Additionally, dig pits filled with mulch or soil were included to replicate natural digging behaviours. Audio enrichment was introduced by placing a portable Bluetooth speaker securely outside the enclosures, offering auditory stimulation that contributed to a more dynamic and engaging environment for the sun bears.

3.3 Plan for data analysis

Behavioural data were analyzed using a combination of quantitative and qualitative methods to provide a comprehensive understanding of sun bear responses to enrichment interventions. Descriptive statistics, including frequency, percentage, and duration of behaviours, were calculated using IBM SPSS (version 26), following standard protocols for behavioural research. Due to the small sample size of only two subjects, descriptive statistics were used to summarize and compare behavioural responses across enrichment conditions. This approach is commonly applied in zoo

animal welfare research where individual-level changes are more informative than population-based inference, and inferential statistics may not be appropriate with such limited samples. Descriptive measures such as mean, median and behaviour frequencies provide meaningful insight into trends in stereotypic and species-typical behaviours under different enrichment conditions (Abdul-Mawah et al., 2022). To evaluate the effects of enrichment, paired sample t-tests were conducted, comparing behavioural patterns before and after the introduction of enrichment devices, in line with commonly accepted practices in confined animal behaviour studies.

All behaviours were systematically coded using a behavioural ethogram, ensuring standardized recording and consistency across observation sessions. The time sampling method was applied, with scan sampling conducted at 1-minute intervals to reduce observer bias and capture temporal patterns in activity.

In addition to quantitative analyses, content analysis was employed to interpret qualitative observations. Notes on behaviours such as novelty response, hesitancy, and interaction with enrichment tools were examined to provide context to the numerical data. These qualitative insights highlighted individual preferences and behavioural nuances, enriching the interpretation of the overall results.

The mean frequency of each observed behaviour was calculated by summing all occurrences recorded during both morning (AM) and afternoon (PM) sessions and then divided by the total number of observation sessions. This procedure was applied to all measures, including stereotypical, exploration, feeding, and other activity patterns. Separate means were calculated for the baseline period and for each enrichment phase, providing an average frequency per session for each behaviour. This approach allows comparison of behavioural responses across different phases and evaluation of the impact of enrichment interventions.

Mean Frequency= Total frequency of behaviour across all AM and PM sessions / Total number of observation sessions

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

- **Mek Bantal**

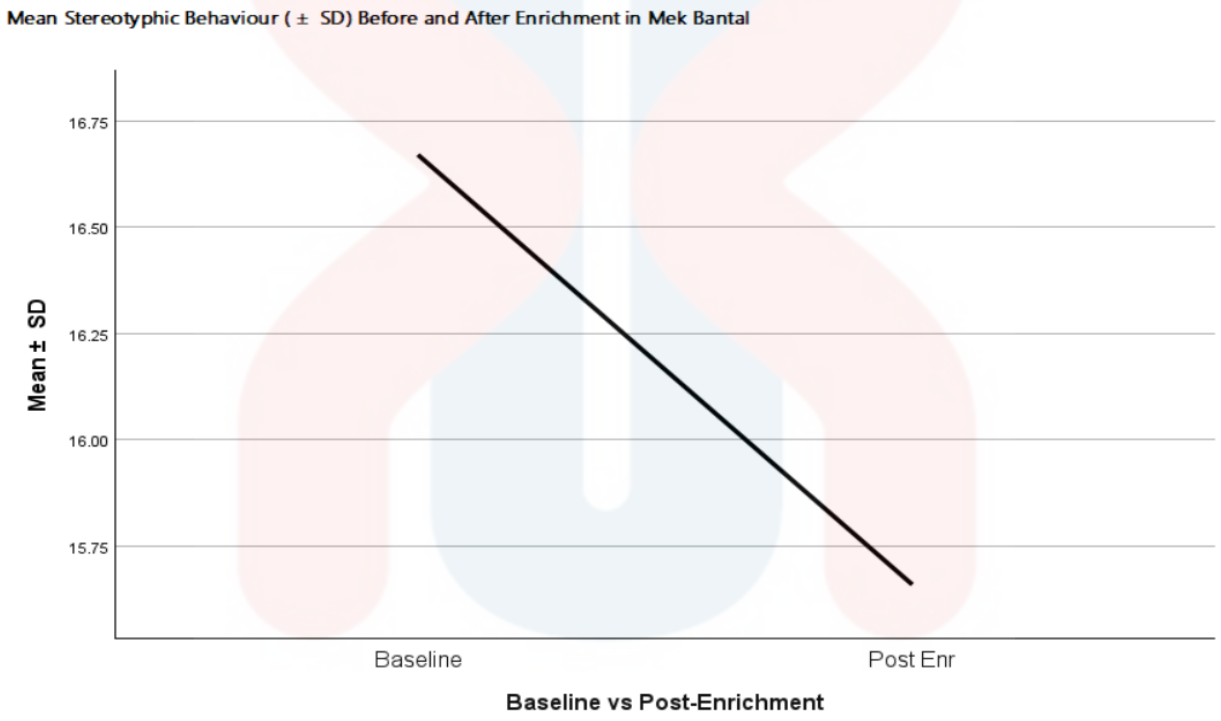

Figure 4.1.1: Line graph of mean stereotypic behaviour before and after enrichment Mek Bantal.

The bar graph compares the overall mean frequency of stereotypic behaviour during the baseline period and the combined post-enrichment sessions (Phases 2–5). The baseline mean was (16.67 ± SD) across 6 sessions, whereas the overall post-enrichment mean was (15.66 ± SD) across 38 sessions. This represents approximately a 6% decrease in stereotypic

behaviour following the enrichment programme. This decline demonstrates that enrichment had a beneficial overall effect on reducing stereotypical behaviour, even when the post-enrichment period included Phase 5, where enrichment was removed and behaviour partially rebounded (16.00 ± SD). Despite this rebound, the overall mean remained lower than baseline, indicating that enrichment produced a measurable and sustained behavioural improvement.

The bar graph therefore supports the conclusion that environmental enrichment effectively reduced stereotypic behaviour in Mek Bantal, and that even after enrichment cessation, the animal did not fully return to baseline stereotypy levels.

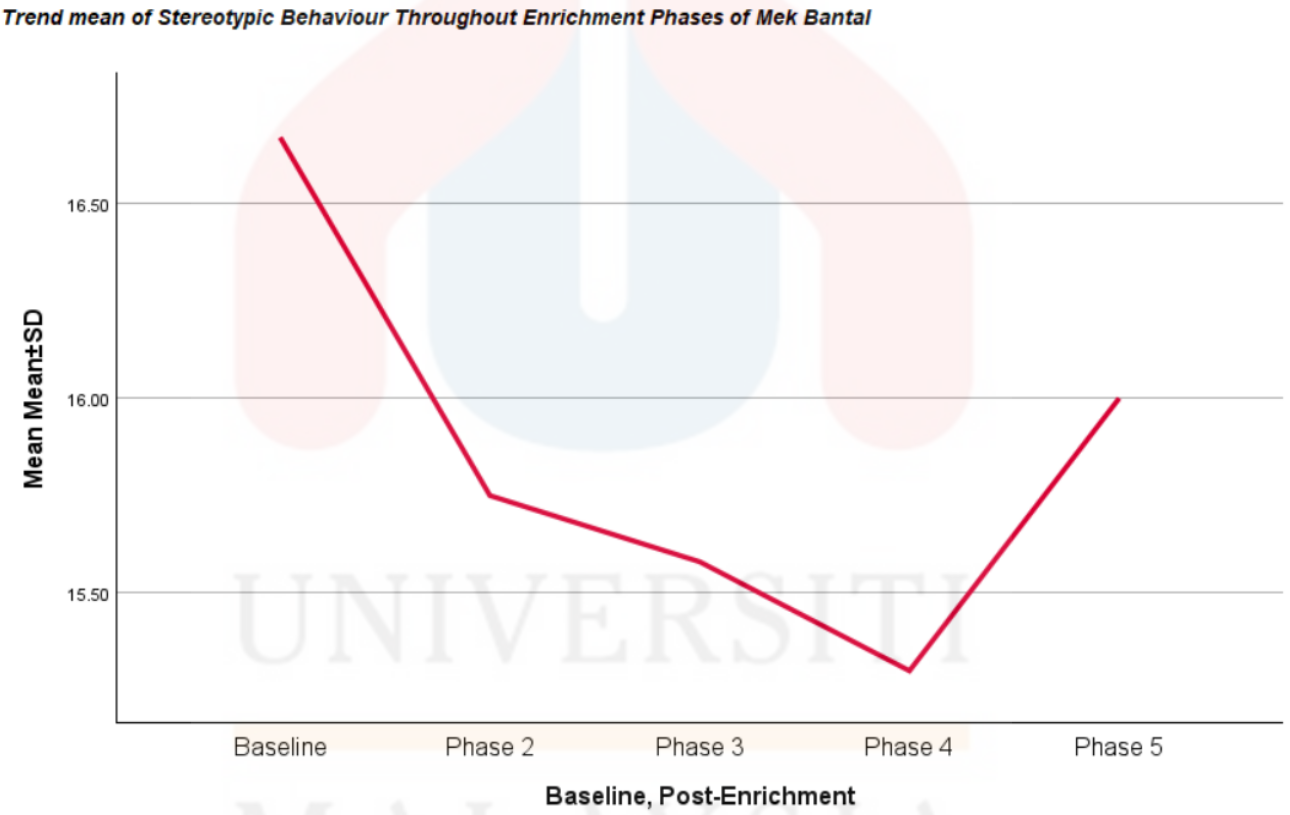

Figure 4.1.2: Line graph that showing trend mean of stereotypic behaviour throughout enrichment phase of Mek Bantal

The line graph illustrates the changes in mean stereotypic behaviour across the baseline and enrichment phases for Mek Bantal. During the baseline period, which consisted of six sessions (AM and PM observations across three days), the mean frequency of stereotypic behaviour was (16.67 ± SD), representing the highest level recorded throughout the study. indicating an elevated level of stress-related repetitive activity prior to enrichment introduction. Following this, a noticeable reduction was seen during the enrichment phases.

In Phase 2 (12 sessions over six days), the mean stereotypic behaviour dropped to (15.75 ± SD), reflecting a mild but meaningful decrease as the bear began interacting with the enrichment provided. This downward trend continued in Phase 3 (12 sessions over six days), with a mean of (15.58 ± SD), suggesting increasing engagement and behavioural stabilization. The lowest stereotypic levels were observed during Phase 4 (10 sessions over five days), with a mean of (15.30 ± SD), demonstrating possibly the most effective response to enrichment throughout the 21-day period. In contrast, Phase 5 (two sessions over one day), conducted with no enrichment present, showed a slight increase in stereotypic behaviour (16.00 ± SD) compared to the enrichment phases. However, this value remained lower than the baseline, indicating that enrichment had a short-term residual positive effect, even when it was temporarily withdrawn.

Throughout the observation period, Mek Bantal was repeatedly observed adopting a vertical cling posture during all enrichment conditions. This behaviour involved maintaining an upright position with the forelimbs supporting the body against the edge of the pool. The posture persisted beyond the active enrichment period and was consistently maintained for most of the post-enrichment observation time, indicating a stable spatial position frequently occupied by Mek Bantal following enrichment exposure.

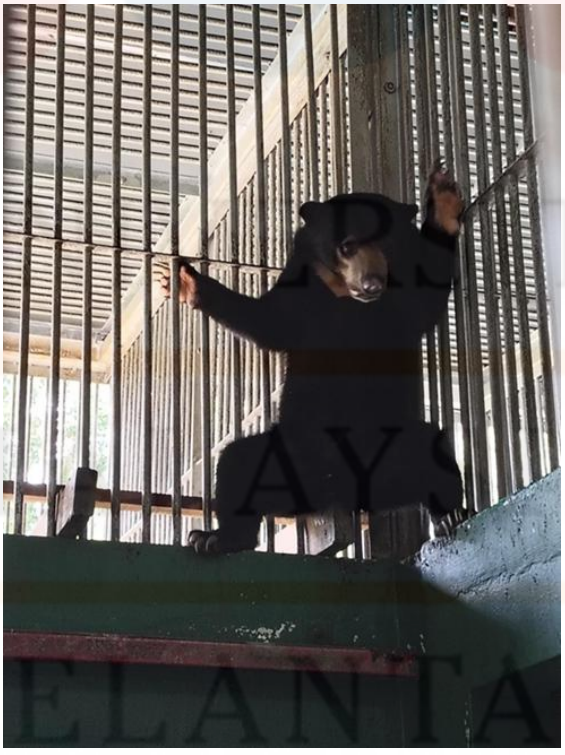

Figure 4.2.1 The image depicts Mek Bantal adopting a vertical cling posture, with the forelimbs supporting the body against the edge of the poll.

Overall, the line graph demonstrates a clear reduction in stereotypic behaviour during enrichment phases, followed by a mild increase during the no-enrichment period, confirming both the effectiveness of the enrichment and the behavioural rebound upon withdrawal.

- **Awe Jerek**

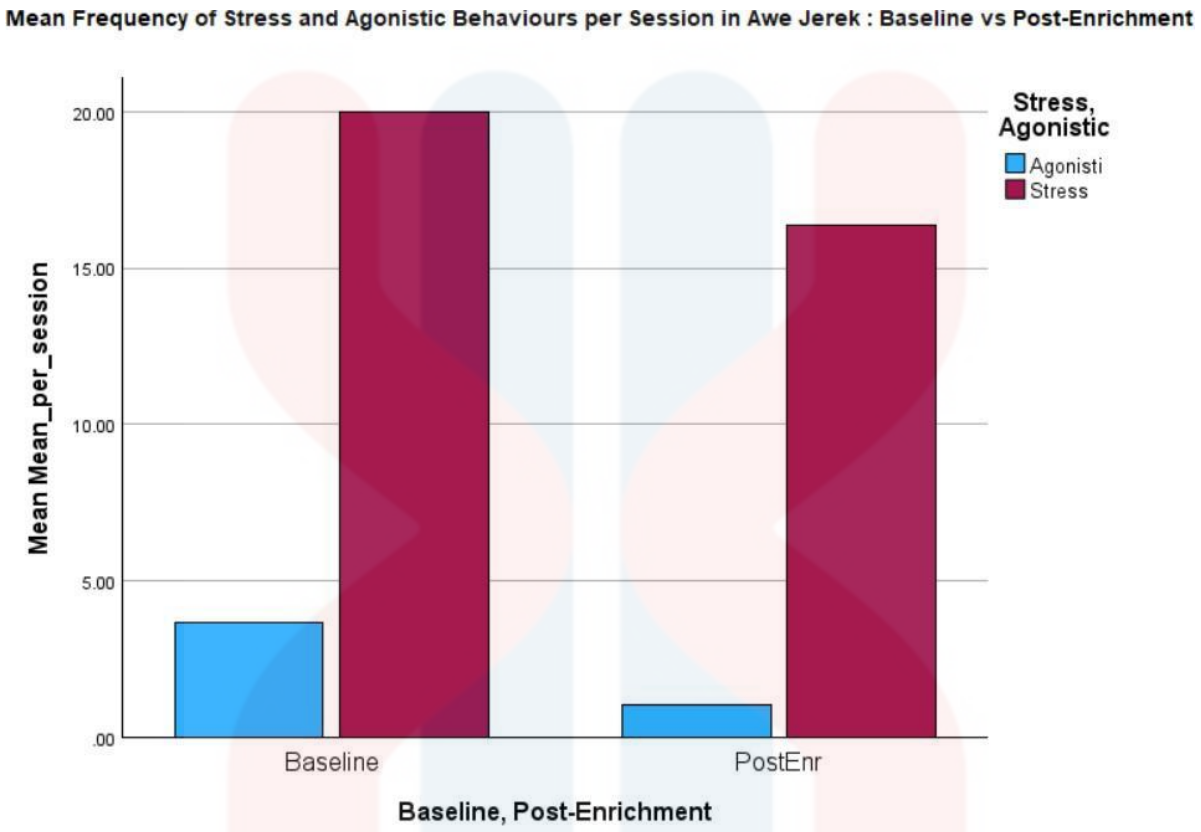

Figure 4.1.3: Bar graph of mean frequency of stress and agonistic behaviours per session in Awe Jerek: Baseline vs post-enrichment

The bar graph provides a clear summary comparing behaviour before and after the enrichment program. When we look at the overall averages, the positive impact becomes very clear. The average stress level decreased from the baseline of (20.00 ± SD) 20.00 to an overall post-enrichment average of (17.63 ± SD) across all the following phases. Even more impressive was the change in aggressive behaviour, which showed a dramatic 72% reduction from the baseline of (3.67 ± SD) down to an overall average of just (1.03 ± SD) after enrichment. This substantial improvement is particularly meaningful because the post- enrichment average includes data from Phase 3 and Phase 4, when aggression was temporarily high at (0.83 ± SD) and (0.80 ± SD) respectively. The fact that the overall average still shows such a strong reduction proves the powerful and lasting positive effect of the enrichment program on Awe Jerek's behaviour.

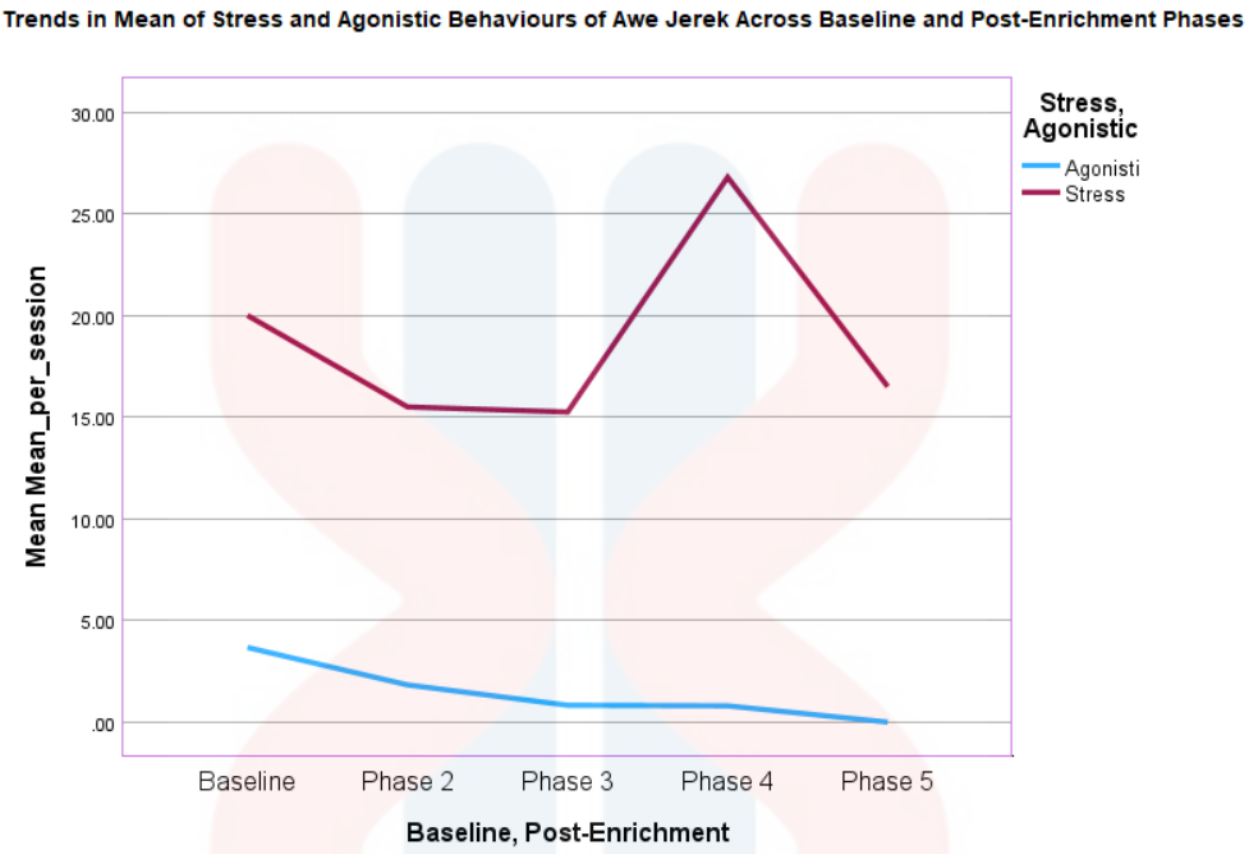

Figure 4.1.4: Line graph shows trend in mean of stress and agonistic behaviours of Awe Jerek across baseline and post-enrichment phases.

The line graph illustrates the nuanced behavioural journey of Awe Jerek across the study's phases, revealing a complex but ultimately successful response to environmental enrichment. The baseline phase established a clear need for intervention, recording the subject's initial stress levels at (20.00 ± SD) and agonistic behaviours at (3.67 ± SD) throughout 3 days (6 sessions: AM & PM).

The introduction of enrichment in Phase 2 (12 sessions over six days) prompted an immediate and positive shift, with stress declining significantly to (15.50 ± SD) and aggression nearly halving to (1.83 ± SD) 1.83, suggesting the initial enrichment was highly effective. However, the trajectory was not linear. In Phase 3 (12 sessions over six days), while stress levels remained low at (15.25 ± SD), a surprising and sharp spike in aggression to (0.83 ± SD) was observed. This divergence indicates a period of behavioural adjustment. This period of instability culminated in Phase 4 (10 sessions over five days), which represented the most challenging phase of stress that surged to its peak at (26.80± SD), potentially indicating enrichment fatigue or neophobia, while aggression remained elevated at (0.80 ± SD). The most critical finding

emerged in Phase 5 (two sessions over one day), following the withdrawal of enrichment. Here, stress levels decreased to (16.50 ± SD) 16.50, settling below the original baseline, and, most significantly, agonistic behaviours were entirely abolished, recorded at (0.00 ± SD).

This final result demonstrates that the enrichment programme facilitated a lasting improvement in behavioural welfare, successfully mitigating aggression and producing a calmer baseline state even in the absence of the enrichment itself.

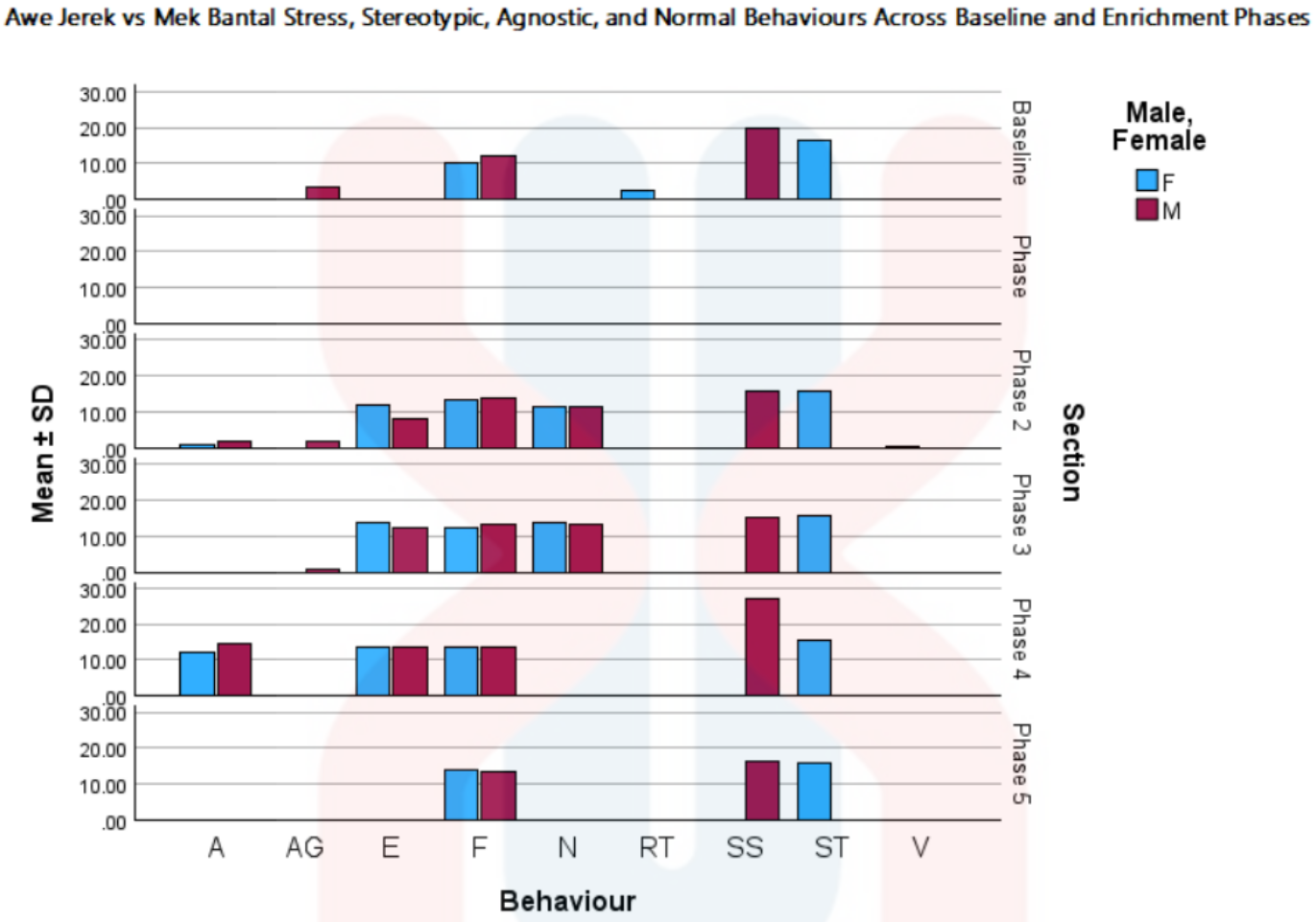

Figure 4.1.5: Cluster Bars illustrate the mean of stress, stereotypic, agnostic and normal behaviours across the baseline and enrichment phase between Awe Jerek and Mek Bantal.

During the baseline period, Mek Bantal displayed the highest levels of stereotypical behaviour (16.67 ± SD), accompanied by relatively low levels of foraging (10.16 ± SD) and resting (2.33 ± SD). Similarly, Awe Jerek showed high stress-related behaviour (20.00 ± SD) with moderate foraging (12.17 ± SD) and some agnostic behaviour (3.67 ± SD).

With the introduction of enrichment in Phase 2, noticeable shifts in behaviour were observed. For Mek Bantal, stereotypic behaviour decreased slightly to (15.75 ± SD), while foraging increased to (13.41 ± SD), and exploration (11.83 ± SD) and novelty interaction (11.58 ± SD) emerged. Minimal vocalization (0.50 ± SD), avoidance (0.83 ± SD), and resting (0.33± SD) suggested that the bear actively engaged with the enrichment items rather than displaying stress or passive behaviours. For Awe Jerek, stress decreased to (15.50 ± SD), foraging increased to (13.75 ± SD), and exploration (7.83 ± SD) and novelty interaction (11.58 ± SD) were noted, while agnostic (1.83 ± SD) and avoidance (1.92 ± SD) behaviours remained low. Awe Jerek tended to begin by foraging for fruits before exploring enrichment items such as coconuts,

banana leaves, or ice cubes with hidden fruits.

During Phase 3, positive trends continued. Mek Bantal's stereotypic behaviour further decreased to (15.58 ± SD), while foraging (14.33 ± SD), exploration (13.66 ± SD), and novelty-related behaviours (13.67 ± SD) increased. Vocalization remained low (0.50 ± SD), indicating sustained focus on enrichment items. Awe Jerek exhibited similar patterns, with stress decreasing to (15.25 ± SD), foraging at (12.25 ± SD), exploration at (12.28 ± SD), novelty (13.10 ± SD) and minimal agnostic behaviour (0.83 ± SD).

Phase 4 demonstrated the lowest stereotypic behaviour in Mek Bantal (15.30 ± SD) and the highest levels of foraging (14.70 ± SD), exploration (13.60 ± SD), novelty interaction (13.60 ± SD), avoidance (12.00 ± SD).Although music enrichment was included during this phase, Mek Bantal showed no behavioural response, continuing to forage and explore, suggesting that auditory enrichment was less effective for this individual compared to foraging or manipulable enrichment. Awe Jerek, in contrast, showed an increase in stress (26.80 ± SD) but continued active engagement in foraging (13.55 ± SD), exploration (13.55 ± SD), novelty interaction (13.10 ± SD), and avoidance behaviours (14.70 ± SD) toward the music enrichment. These patterns highlight individual differences in enrichment preferences, while reinforcing that foraging-based or manipulable enrichment promotes the strongest behavioural improvements in captive Malayan sun bears.

In Phase 5, when no enrichment was provided (one day, two sessions), Mek Bantal exhibited a slight rebound in stereotypic behaviour (16.00 ± SD), although foraging remained high (14.00 ± SD), and Awe Jerek displayed reduced stress (16.50 ± SD) with stable foraging (13.50 ± SD) and absence of agnostic behaviour. The rebound in stereotypy likely reflects the temporary absence of stimuli that satisfies natural behavioural motivations.

4.2 Discussion

The findings of this study provide valuable insight into the behavioural responses of captive Malayan sun bears to various environmental enrichment strategies. During the baseline period, Mek Bantal and Awe Jerek exhibited high levels of stereotypic or stress-related behaviours respectively with relatively low engagement in naturalistic activities such as foraging, exploration, or novelty interaction. This pattern aligns with the first research question, which aimed to determine how the behaviours of captive Malayan sun bears change in response to enrichment, and highlights the need for interventions to promote behavioural diversity and improve welfare. The subsequent introduction of enrichment resulted in clear behavioural changes. Both bears demonstrated increased foraging, exploration, and interaction with novel items, while stereotypic or stress-related behaviours decreased across enrichment phases, supporting the first hypothesis (H1) that enrichment interventions would lead to an increase in exploratory and play behaviours.

Analysis of the effects of distinct enrichment types revealed that food-based enrichment consistently elicited strong engagement in both bears, with exploration and foraging increasing during Phases 2–4. Sensory enrichment, specifically music, elicited minimal behavioural response in Mek Bantal, although Awe Jerek showed some avoidance towards the auditory stimulus, suggesting individual differences in response to sensory-based interventions. This finding partially supports the second and third hypotheses (H2 and H3), indicating that different enrichment types have distinct effects, with structured enrichment particularly food-based or manipulable items being most effective in reducing stereotypic behaviours, while sensory enrichment may be less impactful depending on individual preference or familiarity.

In the baseline, the patterns indicate in the absence of enrichment showing Mek Bantal was more likely to engage in repetitive behaviours while Awe Jerek showing stress-related behaviour with limited naturalistic activities, highlighting the need for enrichment to increase behavioural diversity and improve welfare in captive settings. In the phase 2, the changes pattern suggests that enrichment successfully redirected the bears' attention toward naturalistic behaviours, reducing reliance on stress or stereotypy as coping mechanisms. For Mek Bantal the avoidance behaviours were observed specifically toward lemongrass enrichment when placed on the floor or wooden stairs, indicating

selective interaction depending on placement. For Awe Jerek, it also showed a strong dislike toward the lemongrass and pandan leaves by refusing to sit inside the blue barrel throughout the morning due to the smell of lemongrass and pandan inside the blue barrel as previously the blue barrel was the placement of those things in the morning.

In phase 3, repeated exposure to enrichment strengthened engagement with natural behaviours, promoted behavioural stabilization, and further reduced stereotypic and stress-related behaviours. In phase 4 (Auditory Enrichment), a contrasting behavioural response is observed which highlights clearly individual differences in sensory processing for both sun bear and stress expression in Awe Jerek.

During phase 4, Awe Jerek's increase in stress-related and agonistic behaviours during auditory enrichment indicates that the acoustic stimulus functioned as a stressor rather than a calming stimulus. As a highly reactive individual, Awe Jerek appears to possess heightened auditory sensitivity; thus, the introduction of novel or unpredictable sound likely triggered hypervigilance, avoidance, and agitation. Similar findings have been reported in zoo-housed primates, where exposure to unfamiliar or inconsistent auditory stimuli suppressed normal foraging behaviour and increased vigilance, demonstrating that certain sounds can act as behavioural disruptors rather than enrichment (Steinbrecher et al., 2023). This suggests that the auditory stimuli in this study may have exceeded Awe Jerek's tolerance threshold, activating a stress-mediated behavioural pathway instead of promoting relaxation. In addition, his reliance on vigilance and agonistic behaviour as primary coping strategies means that auditory enrichment interrupts his normal behavioural pattern, thereby amplifying stress rather than mitigating it.

In contrast, Mek Bantal exhibited a reduction in stereotypic pacing compared to baseline, but the decrease remained minimal, indicating that auditory enrichment had only a mild influence on her welfare state. Mek Bantal consistently expresses stress through pacing, a highly ingrained stereotypic behaviour that is often resistant to change unless provided with strong, engaging enrichment. The slight reduction suggests a modest calming effect, yet the stereotypy persisted near baseline levels because the stimulus lacked the behavioural relevance required to override a habitual coping mechanism.

The divergent responses during auditory enrichment underscore the importance of individual-specific enrichment strategies. While Awe Jerek was overstimulated by the stimulus, leading to heightened stress, Mek Bantal experienced only marginal improvement due to the low behavioural engagement provided by sound-based enrichment. These findings emphasize that enrichment must be tailored to the sensory preferences, coping styles, and behavioural histories of each individual bear to achieve meaningful welfare improvements. Very few studies have examined auditory enrichment in bears specifically (or at least published). Most enrichment studies focus on feeding, structural, olfactory, or cognitive enrichment. So, evidence for sound-based enrichment effects, especially for stress, is limited. Future studies should explore different categories of auditory stimuli, vary predictability and duration of sound exposure, and assess animal-controlled or individually tailored auditory enrichment, alongside physiological stress measures, to better determine its welfare relevance.

The observed reduction in stereotypical behaviours may be influenced by the cumulative effect of continuous enrichment, as the bears were exposed to multiple enrichment types in succession (Ghavamian et al., 2022b). However, due to the limited observation period, it is not possible to be 100% certain that the lowest levels of stereotypic behaviour were fully captured, and the results may not reflect the long-term effects of enrichment. A more robust approach would involve introducing a single type of enrichment, followed by a period without enrichment, before introducing a different type of enrichment, allowing for clearer assessment of each intervention's impact (Williams et al., 2017). Alternatively, using different individuals to test different enrichment strategies could help control individual preferences and provide more accurate evaluation of the effectiveness of each enrichment type (Cremers et al., 2025).

Phase 5, conducted without enrichment, showed a slight rebound in stereotypic or stress-related behaviours, although levels remained lower than baseline. This indicates a short-term residual effect of prior enrichment exposure, demonstrating that enrichment can produce temporary welfare improvements even when withdrawn (Aguiar et al., 2025). These results underscore the importance of providing continuous or regularly rotated enrichment to sustain long-term behavioural improvements and promote species-typical behaviours, in line with the study objectives. These results emphasize the importance of providing continuous or regularly rotated enrichment to

sustain behavioural improvements and overall welfare.

Behaviourally, this suggests that the enrichment contributed to reducing stereotypy not only in the moment but also beyond the immediate exposure period. This rebound indicates a partial return towards baseline levels once enrichment was withdrawn. This pattern supports the conclusion that enrichment was directly responsible for the reduction seen in the earlier phases.

Based on my observation, the differences in effectiveness among enrichment types can be attributed to the natural behavioural tendencies and preferences of each bear. Food-based and manipulable enrichment consistently elicited strong engagement, as both Mek Bantal and Awe Jerek were highly motivated by foraging and problem-solving opportunities. These types of enrichment allowed the bears to express species-typical behaviours such as exploration, manipulation, and searching for hidden food, which effectively reduced stereotypic and stress-related behaviours (Wong et al., 2022). In contrast, sensory enrichment, specifically music, was less effective. Mek Bantal showed minimal response, and Awe Jerek exhibited avoidance behaviours toward the auditory stimulus, suggesting that not all sensory enrichment items are equally stimulating or appealing, and individual preferences can significantly influence outcomes. This highlights the importance of tailoring enrichment programmes to the specific interests and behavioural needs of each animal, rather than assuming a single enrichment type will be universally effective.

An additional observation was that both bears exhibited less agnostic behaviour and vocalization over time when handled or observed by the same familiar person. This suggests that habituation to the caregiver or observer reduced fear-related responses and stress triggers, contributing to a calmer behavioural state. This finding highlights the role of consistent human interaction in complementing enrichment strategies and improving welfare (Coria-Avila et al., 2022).

It is also important to note that paired sample t-tests were initially planned to statistically compare behaviours before and after enrichment interventions. However, the analysis could not be conducted due to two primary reasons: the small sample size (n=2) and the differences in behavioural categories between the bears Mek Bantal primarily exhibited stereotypic behaviours, whereas Awe Jerek exhibited stress-related and agnostic behaviours. Additionally, the limited number of sessions per phase restricted the ability

to perform robust inferential statistical tests (Chapter 10 Assumptions of Parametric Tests | Advanced Statistics I & II, n.d.-b). As a result, all findings are presented descriptively, using mean frequencies and observed trends. Despite the lack of statistical testing, the descriptive data clearly demonstrate consistent behavioural improvements in response to enrichment.

The observed patterns have important welfare implications. Providing enrichment that aligns with the animals' natural behaviours not only reduces negative stress-related and stereotypic activities but also promotes active engagement, exploration, and cognitive stimulation (Archer et al., 2025). The partial rebound of stereotypical or stress-related behaviours when enrichment was withdrawn further underscores the necessity of continuous or regularly rotated enrichment programmes to maintain welfare benefits over time.

Overall, the observed behavioural changes confirm that environmental enrichment contributes to reductions in stereotypic and stress-related behaviours while promoting naturalistic activities such as foraging, exploration, and novelty interaction. Food-based and manipulable enrichment items were the most effective, whereas auditory enrichment produced variable responses, highlighting the importance of tailoring enrichment to individual preferences. The slight rebound in stereotypic and stress-related behaviours during the no-enrichment phase further underscores the bears' dependence on stimulation and the need for structured, varied, and consistent enrichment programmes. These findings provide evidence-based recommendations for enrichment protocols that can enhance the welfare of captive Malayan sun bears, fulfil the study's research objectives and support the expected outcomes outlined in the hypotheses.

The observation that Mek Bantal frequently adopted a vertical cling posture, with forelimbs supporting the body against the pool edge, is noteworthy even though it was not part of the formal behavioural parameters measured. To our knowledge, no previous studies have reported or investigated this specific posture in sun bears or other large mammals. This posture may represent a form of self-stimulation, postural comfort, or coping behaviour, potentially linked to stress, boredom, or individual physical preference. While causality cannot be definitively determined, the introduction of enrichment may have influenced Mek Bantal's motivation to explore or interact with the environment, thereby promoting the adoption of this posture. However, without targeted observation and systematic quantification, it is not possible to conclude whether this posture reflects improved welfare, stress relief, or a response to novelty. Future studies could include

detailed postural observations as supplementary behavioural parameters to better understand the link between enrichment and behavioural expression in captive sun bears.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The findings of this study demonstrate that environmental enrichment effectively reduced stereotypic and stress-related behaviours in captive Malayan sun bears while promoting species-typical activities such as foraging, exploration, and interaction with novel items. Mek Bantal showed high baseline levels of stereotypic behaviour, which gradually decreased across enrichment phases, with strong engagement in foraging and exploration but minimal response to auditory enrichment. Awe Jerek exhibited high baseline stress and some agnostic behaviours, which also declined with enrichment, particularly when engaging with food- based and manipulable items, although he showed occasional avoidance to music enrichment. Both bears displayed reduced vocalization and agnostic behaviour over time when interacting with familiar caregivers, indicating habituation and reduced fear responses. Despite a slight rebound in stereotypic or stress-related behaviours during the no-enrichment phase, levels remained lower than baseline, highlighting the short-term residual benefits of enrichment. Overall, these observations confirm that structured, varied, and consistent enrichment programmes significantly enhance the welfare of captive Malayan sun bears, while accounting for individual differences in behavioural responses.

5.2 Recommendations

To maximize welfare benefits, enrichment programmes for captive Malayan sun bears should prioritize food-based and manipulable items that encourage natural foraging, exploration, and problem-solving. Enrichment should be rotated regularly to maintain novelty and engagement, and individual preferences should be considered when introducing new sensory or cognitive stimuli.

Enrichment at the NWRC should be implemented on a structured rotation schedule to maximize novelty and engagement. For instance, enrichment types could be rotated on a weekly basis, with one week focused on food-based enrichment (seasonal fruit or hidden treats), the next on cognitive or problem-solving enrichment (puzzle feeders), followed by structural or sensory enrichment (climbing structures, scent trails, or auditory stimuli).

Within each week, multiple items or variations of the enrichment type can be alternated daily to maintain interest and prevent habituation. Additionally, individual preferences and behavioural responses should be monitored to tailor enrichment for each bear, ensuring overstimulation is avoided while promoting positive welfare outcomes.

Introducing a short washout period of a few days without enrichment between phases can help bears return to baseline behaviours before testing new interventions. This ensures that observed responses are due to the current enrichment type rather than carryover effects from previous interventions. Continuous monitoring of behavioural responses should inform adjustments to enrichment type, intensity, and rotation frequency, ensuring that enrichment is stimulating but not stressful, particularly for highly reactive individuals.

Additionally, consistent interaction with familiar caregivers should be maintained to reduce stress, agnostic, and vocalization behaviours. Enrichment should form part of a broader welfare programme, including appropriate housing, diet, and veterinary care, to support both the physical and psychological well-being of captive Malayan sun bears. Future research should aim to include larger sample sizes, longer observation periods, and quantitative measures to strengthen evidence-based enrichment recommendations.

Furthermore, providing larger enclosures and wider night stalls will allow bears to explore, move freely, and engage more naturally with enrichment items, further enhancing their overall welfare and reducing stress-related or stereotypic behaviours. Future research should include larger sample sizes, extended observation periods, and quantitative measures to strengthen evidence-based enrichment recommendations and to further explore individual variability in responses.

5.3 Limitation

This study presents several limitations that may influence the interpretation of the behavioural outcomes. Firstly, the rebound of stereotypical behaviours may not have been fully captured due to the relatively short observation period following the cessation of enrichment. If the post-enrichment monitoring period had been extended, the re-emergence or intensification of stereotypic behaviours might have been more apparent, providing a clearer understanding of how long the enrichment effects persist once stimuli are removed.

Secondly, the cumulative effect of administering different enrichment types in close succession may have introduced bias into the behavioural data. Continuous enrichment without a sufficient washout period

between phases can lead to overlapping effects, where behavioural improvements or reductions in stereotypy may be influenced by the combined or lingering impact of previous enrichments rather than the specific enrichment being evaluated. Ideally, each enrichment type would be followed by a pause period to allow behaviour to return to baseline, ensuring clearer differentiation of treatment effects.

5.4 Contribution

Compared to many previous studies on sun bear behaviour, which often focus broadly on captive management or general behavioural descriptions, this research will provide a more focused, practical, and applied evaluation of enrichment effectiveness specifically within the Malaysian context. Because enrichment studies on Malayan sun bears are limited, especially those conducted directly at the National Wildlife Rescue Centre (NWRC), this project fills an important knowledge gap by generating site-specific data that reflect real management conditions.

By documenting baseline stereotypies and assessing how targeted enrichment reduces these behaviours, the study offers immediate, actionable information that can improve daily husbandry routines at NWRC. This evidence helps caretakers identify which enrichment types are most beneficial, allowing them to prioritize resources, reduce stress-related behaviours, and promote more natural activity patterns. The project strengthens sun bear welfare at NWRC by providing practical recommendations that can be directly implemented to enhance the physical and psychological well-being of bears, contributing to long-term improvements in captive welfare standards.

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APPENDIX A

Appendix A1: The map view of NWRC.

Appendix A2: The map view of the entire enclosure sun bear in the NWRC.

Appendix A3: The full sun bears outdoor enclosure from the above view ((Izzat-Husna et al., 2022).

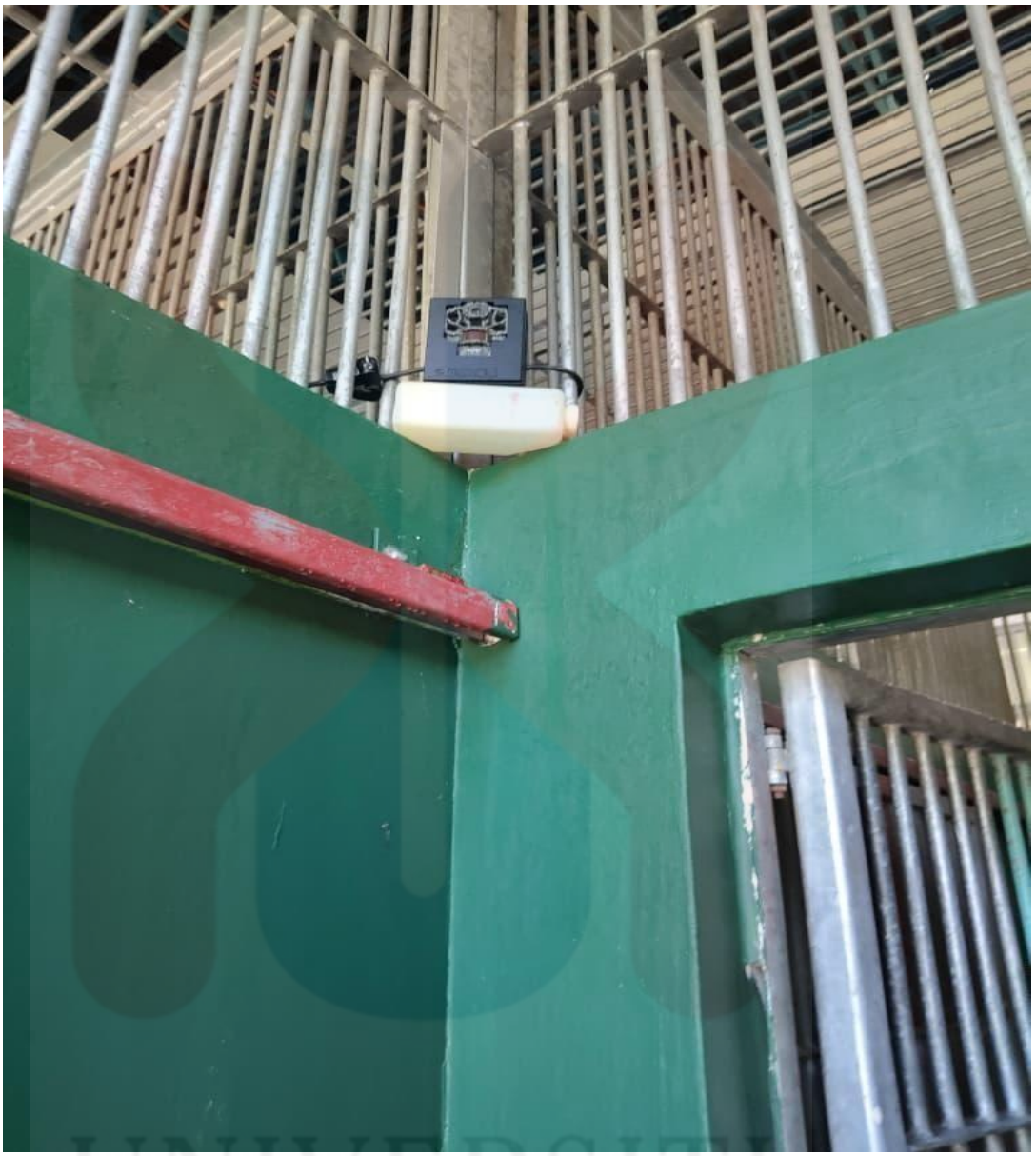
Appendix A4: This is the entrance view of the NWRC.

Appendix A5: Awe Jerek was sitting on the wooden platform and avoided sitting inside the blue barrel due to the presence of the smell of lemongrass and pandan.

Appendix A6: Showing the setting of the phone with a tripod to record the behavior of the Awe Jerek.

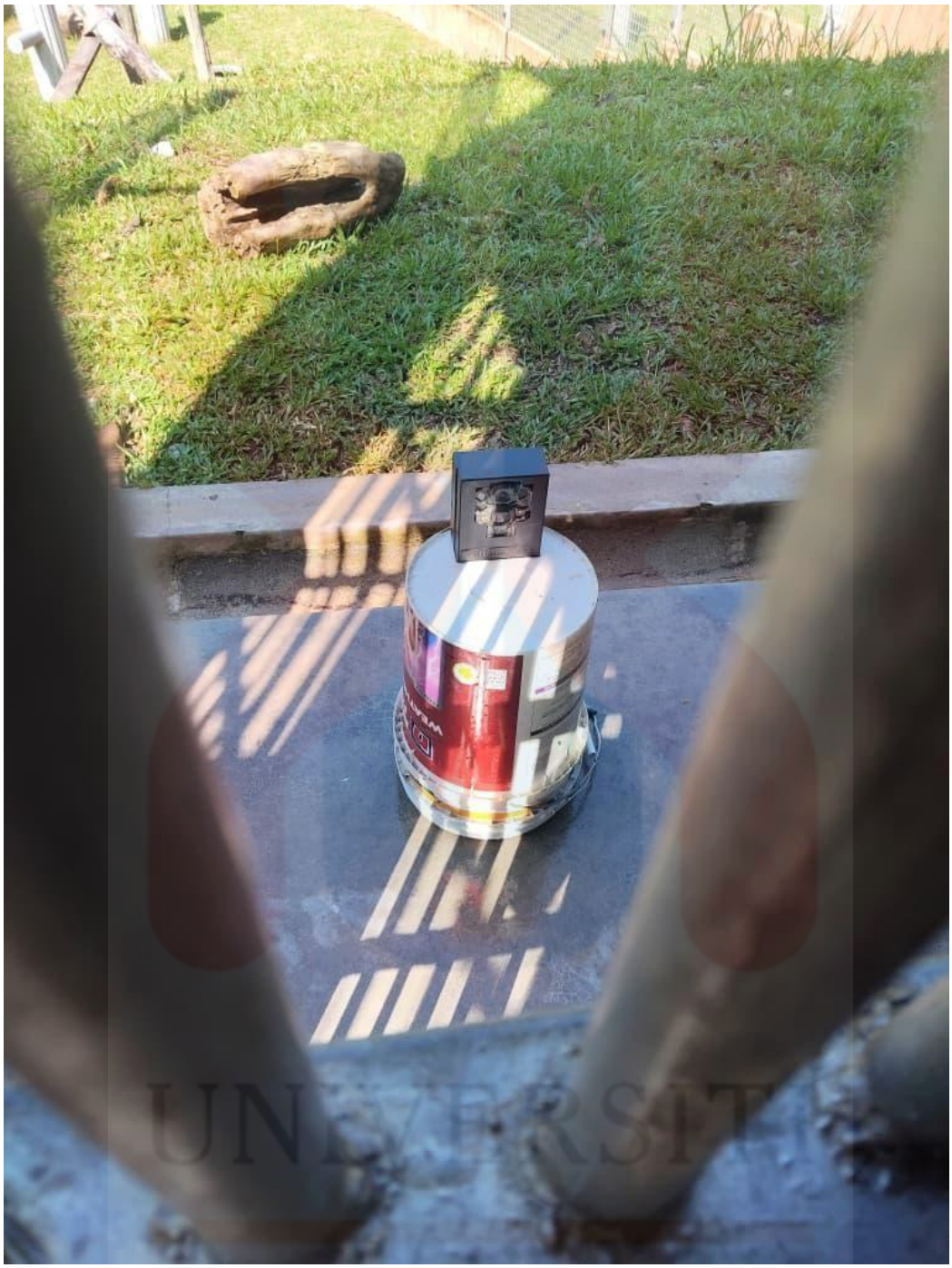
Appendix A7: This is the detail board of the Awe Jerek that was put beside the night stall.

Appendix A8: This is the night stall of Awe Jerek where the enrichment was conducted.



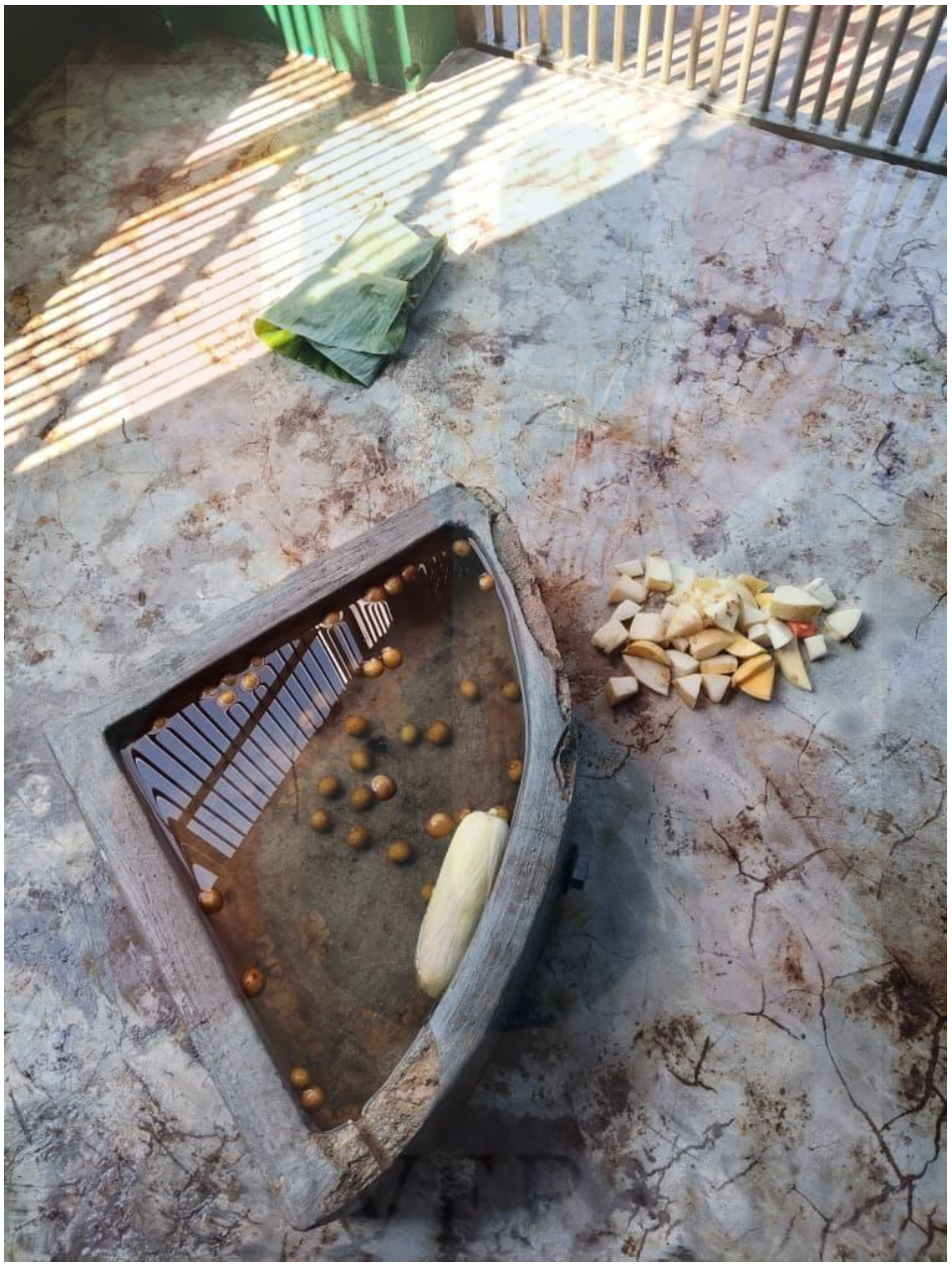
A

Appendix A8: Showing the placement of the camera trap to record the behaviour of Mek Bantal.



Appendix A9: Showing the placement of the camera trap to record the behaviour of Mek Bantal.

Appendix A10: This is the detail board of the Mek Bantal that was put beside the night stall.



Appendix A11: The cut fruits were placed on the floor of the night stall and there were some fruits hidden inside the banana leaves for dig pit enrichment.

PERHILITAN

JABATAN PERLINDUNGAN HIDUPAN LIAR DAN TAMAN NEGARA

DEPARTMENT OF WILDLIFE AND NATIONAL PARKS

A-00343-15-25

PERMIT PENYELIDIKAN ATAU KAJIAN KE ATAS HIDUPAN LIAR-AKADEMIK(DILINDUNGI)

SEKSYEN 10(1)(A)

AKTA PEMULIHARAAN HIDUPAN LIAR 2010 [AKTA 716]

BUTIRAN PEMILIK

NAMA PEMILIK : DILASHINEE A/P CHELLADURAI
NO MYKAD / PASPORT : 020104080876
PEKERJAAN : PELAJAR
ALAMAT PREMIS : UNIVERSITI MALAYSIA KELANTAN KAMPUS KOTA 16100 KOTA BHARU 16100-KOTA BHARU, KELANTAN

NAMA SYARIKAT : UNIVERSITI MALAYSIA KELANTAN
NAMA PREMIS :
NO PENDAFTARAN PREMIS :

TEMPOH SAH

12/12/2025 - 31/01/2026

Syarat-Syarat Permit Penyelidikan Atau Kajian Ke Atas Hidupan Liar-Akademik (Dilindungi)

Terms and Conditions for Research or Study Permit on Wildlife - Academic (Protected)

1. Permit ini tidak boleh dipindah milik.
   This permit is non-transferable.
2. Permit ini sah untuk tempoh yang telah dinyatakan pada permit.
   This permit is valid for the period specified on the permit
3. Permit ini hanya sah bagi kajian spesies yang dinyatakan sahaja.
   This permit is only valid for the study of the specified species only.
4. Ketua Pengarah boleh menggantung atau membatalkan permit jika pemegang permit melanggar syarat-syarat yang telah dinyatakan.
   The Director General may suspend or revoke the permit if the permit holder violates the conditions that have been stated
5. Pemegang tertakluk kepada peruntukan Akta Pemuliharaan Hidupan Liar 2010 (Akta 716) dan apa-apa perintah yang pada masa itu berkuatkuasa.
   The holder is subject to the provisions of the Wildlife Conservation Act 2010 (Act 716) and any orders in force at the time.
6. Pemegang permit perlu membuat permohonan permit yang baharu dalam tempoh empat belas (14) hari dari tarikh tamat tempoh sah permit.
   The permit holder must apply for a new permit within fourteen (14) days from the expiry date of the permit.

Syarat-Syarat Tambahan

Additional Terms and Conditions

1. Rakan saing dan co-author yang dilantik bagi membantu serta memantau perjalanan penyelidikan ini ialah Dr. Zubaidah binti Kamarudin, Pegawai Veterinar (Pusat Menyelamat Hidupan Liar Kebangsaan, NWRC).
2. Berkongsi hasil penyelidikan, data berserta laporan/penerbitan kertas saintifik/tesis dengan Jabatan melalui rakan saing.
3. Penyelidikan ini dapat memberi manfaat/membantu kepada pengurusan Jabatan.

Penyedia: ABDUL AZIM BIN AHMAD TERMIZI
Pelulus: DR. PAZIL BIN ABDUL PATAH

Ini adalah cetakan komputer dan tidak perlu ditandatangani

Appendix A12: The permit letter to the final year project at NWRC, Sungkai