

## A Review of Mammalian Availability as Salt-Lick Tourism Supply

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**Abstract:** A wide range of mammal species visit to mineral licks, thus salt-lick tourism is promoted to allow clear-viewing of free-roaming mammal individuals by tourists at the licks. However, there is lacking in information on the factors that define overall satisfactions of tourists during mammal-watching at mineral licks, as well as the means to evaluate this matter. Henceforth, this paper intends to provide a holistic understanding on the keystone factors that define mammalian availability as salt-lick tourism supply. The authenticity, uniqueness, intensity, duration, species popularity and rarity of sighted mammal individuals shape the overall satisfactions of tourists, and then these criteria can be represented by physical availability, species traits and diversity of mammals that can be sighted at a mineral lick. Then, temporal variability in bio-physiochemical, environmental and anthropogenic conditions are determined to determine the availability of a mammal species at a particular mineral lick. Tourist perception towards geophagic behaviour of mammals and tourist carrying capacity for mammal-watching at the licks have yet been addressed at this moment, henceforth further research is required to fill up these research gaps for this field of study in future.

**Keywords:** Mammalian Availability, Salt-Lick Tourism, Spatial-Temporal Variability, Supply-Demand

### INTRODUCTION

Nature-based tourism that aims to provide tourists with opportunities to view free-roaming wildlife individuals at a mineral lick is regarded as “Salt-lick Tourism” [2, 3]. The open environment of a mineral lick allows high chance and clear viewing of the large-sized mammals at their natural habitats [14]. Thanks to that, mineral licks are acknowledged as mammal-watching hotspots [15], which have led to the emergence of salt-lick tourism in the global wildlife tourism market in recent years.

Since that this niche tourism is introduced recently as a sub-form of wildlife-watching tourism, hence the information regarding salt-lick tourism remains scarce at this moment. To date, only the activity preference of tourists at the licks was investigated by past researchers [2, 3], in which mammal-watching was not the primary activity for tourists when visiting to the licks. Reynolds and Braithwaite [42] emphasized that a wildlife species with trait uniqueness and highly available for sighting by tourists were considered ideal as a “tourism product” for a wildlife-watching destination [4, 29, 49]. Hence, it is crucial to further assess the mammal species that are available as tourism supply at a mineral lick. Likewise, viewing success of mammal individuals by the tourists could positively enrich their satisfactions [3], however the difference in satisfaction levels of tourists brought by different sighted wildlife species remained unknown

at the mean time. Likewise, the physical availability of a mammal species was affected by temporal variability in both onsite and surrounding conditions of a mineral lick [7, 21, 24, 33, & 38]. Henceforth, this paper intends to provide a holistic understanding on keystone factors that define mammalian availability as tourism supply at a mineral lick. Research gaps of this field of study are highlighted at the end of this paper review.

### Mammalian Availability as Salt-Lick Tourism Supply

To date, a majority of past studies focused on studying mammal-lick relationship, since the early 1970s [5, 20, 23, 30, 35, 41, & 46]. Reynolds and Braithwaite [42] emphasized that the authenticity, intensity, uniqueness, duration, species popularity and status of encountered wildlife individuals shaped overall tourist satisfactions. Based on the given statement, species diversity, species attributes (e.g.: behavioural, morphological and identity traits), and physical availability (e.g.: visiting duration and frequency, relative abundance, and group size) of mammals were frequently applied as representations of mammalian availability at a destination site [4, 29, 49]. Table 1 shows the definitions and relations of keystone criteria that define overall satisfactions and expectations of tourists towards salt-lick tourism.

Table 1: Definitions and relations of keystone factors that shaped overall tourist satisfactions towards salt-lick tourism (Source: Reynolds & Braithwaite [42]).

<b>Factor</b>	<b>Definition</b>	<b>Relation to Salt-lick Tourism</b>
<b>Authenticity</b>	Genuineness of wildlife behaviour and setting viewed by tourists.	The encountering of mammal individuals with altered behaviours and at mineral licks surrounded by non-native tree stands or disturbed forests will negatively impact tourist satisfactions over the tourism activity or destination, and vice versa.
<b>Intensity</b>	Extent of anticipation showed by tourists over the tourism activity or destination.	Increasing in anticipation of tourists in sighting rare mammal species will positively increase satisfaction levels of tourists to the tourism activity or destination, and vice versa.
<b>Uniqueness</b>	Degree of integrity perceived by tourists towards their experiences in wildlife-watching.	Tourist individuals that manage to experience things that are different from others will demonstrate higher satisfactions at the end of the tourism activity, and vice versa.
<b>Duration</b>	Length of time that the tourists are exposed to presences of wildlife.	The sighting of wildlife individuals for a long period of time will positively enrich tourist satisfactions over the tourism activity or destination, and vice versa.
<b>Species Popularity</b>	Marketability of a wildlife species perceived by tourists, based on its physical and identity uniqueness, and its publicity in social media.	The sighting of Proboscis Monkey, an endangered and endemic species of Borneo with physical uniqueness, will positively enrich tourist satisfactions towards the tourism activity or destination, thanks to the perceived popularity of Proboscis Monkey.
<b>Species Status</b>	Existing conservation status that is assigned to a wildlife species.	Satisfaction levels of tourists will be higher when they manage to encounter threatened wildlife species than non-threatened species at mineral licks.

## RESEARCH METHODOLOGY

This paper review intends to discuss about the keystone factors that define the mammalian availability for salt-lick tourism. Therefore, 30 past studies that focused on assessing mammal-lick relationship were selected as the review materials for this paper review. Google Scholar and ScienceDirect.com was applied to search for given past articles, based on keywords liked “Mineral Lick”, “Salt-lick”, “Mammal + Mineral Lick”, and “Wildlife + Salt-lick”. These review materials were then reviewed, based on the 1) Parameters that represented mammalian availability, and; 2) explanatory variables used in given past studies. Table 2 shows the summary of the selected past studies with parameters that represent mammalian availability and explanatory variables respectively.

### Parameters That Represent Mammalian Availability

With referred to Table 2, a total of six parameters were applied by the selected review materials in representing

mammalian availability at mineral licks. Most of these past studies employed four out of six parameters, where visiting frequency was used most frequently (28 or 93.3 % past studies), followed by species traits (26 or 86.7 % past studies), and then the visiting duration (40.0 % or 12 past studies), and the species diversity (10 or 33.3 % past studies). Both relative abundance and group size were equally applied the least (9 or 30.0 % past studies) by past researchers in this field of study. Behavioural, morphological and identity characteristics affected the expectations of tourists in wanting to sight a mammal species, while physical availability, in terms of relative abundance or visiting frequency, visiting duration, and group size, affected the quality, quantity and probability of viewing the given species by tourists, at a destination site [4, 29, 42, 48, & 49]. Because of that, mammalian availability for salt-lick tourism can be represented by the six mentioned parameters, which can be evaluated quantitatively (group size, relative abundance, species richness, visiting frequency, and visiting duration) and qualitatively (morphological, behavioural and identity traits) respectively [21, 24, 35].

Table 2: Summary of selected mammal-lick relationship past articles with parameters that represent mammalian availability and explanatory variables respectively.

Reference	Mammalian Availability						Explanatory Variables						
	Visiting Duration	Group Size	Species Trait	Visiting Frequency	Relative Abundance	Species Diversity	Salt Lick Properties	Food Source and Nutrient	Weather Condition	Time of the Day	Human/Predation Pressure	Season	Surrounding Environment
Hebert & Cowan, 1971	✓	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-
Tankersley & Gasaway, 1983	✓	-	✓	✓	-	-	✓	-	✓	✓	✓	✓	-
Moe, 1993	-	-	-	✓	-	-	✓	-	-	-	-	-	-
Ramachandran <i>et al.</i> , 1995	-	-	✓	-	-	-	✓	-	-	-	-	✓	-
Clayton & MacDonald, 1999	✓	✓	✓	✓	✓	-	✓	-	-	✓	-	✓	-
Matsubayashi <i>et al.</i> , 2007a	-	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
Matsubayashi <i>et al.</i> , 2007b	-	-	✓	✓	-	-	-	-	-	✓	-	✓	-
Ayotte <i>et al.</i> , 2008	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	-
Voigt <i>et al.</i> , 2008	-	-	✓	✓	-	-	✓	-	-	-	-	-	-
Blake <i>et al.</i> , 2010	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	-
Blake <i>et al.</i> , 2011	-	-	✓	✓	-	✓	-	-	✓	✓	-	✓	-
Link <i>et al.</i> , 2011	✓	✓	✓	✓	-	-	-	-	✓	✓	-	✓	-
Matsubayashi <i>et al.</i> , 2011	✓	-	✓	✓	✓	-	✓	-	-	✓	✓	-	✓
Ping <i>et al.</i> , 2011	✓	✓	✓	✓	-	-	-	-	-	✓	-	✓	-
Lameed & Adetola, 2012	-	-	-	✓	-	✓	✓	-	-	-	-	-	-
Blake <i>et al.</i> , 2013	-	-	✓	✓	-	✓	-	-	-	✓	✓	-	✓
Hon & Shibata, 2013	-	-	✓	✓	✓	-	-	-	-	✓	-	-	-
Bashir Ali, 2014	-	-	✓	✓	-	✓	-	-	-	✓	-	-	-
Chew <i>et al.</i> , 2014	-	-	✓	-	-	-	-	✓	-	✓	-	-	-
Molina <i>et al.</i> , 2014	-	-	✓	✓	-	✓	✓	-	-	✓	-	-	-
Ajayi & Ogunjobi, 2015	-	-	✓	✓	✓	-	✓	-	-	✓	-	-	-
Magintan <i>et al.</i> , 2015	-	-	-	✓	-	✓	-	-	-	-	-	-	-
Matsuda <i>et al.</i> , 2015	-	-	✓	✓	✓	✓	✓	-	-	-	-	✓	-
Jokinen <i>et al.</i> , 2016	✓	-	✓	✓	-	-	✓	-	-	✓	-	✓	-
King <i>et al.</i> , 2016	✓	✓	✓	✓	✓	-	-	-	-	✓	-	-	-
Hii, 2017	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✓	-
Bansa <i>et al.</i> , 2018	✓	-	✓	✓	✓	-	✓	-	-	-	-	-	-
Journeaux <i>et al.</i> , 2018	-	✓	✓	✓	-	-	-	-	✓	-	✓	✓	✓
Bakri <i>et al.</i> , 2019	-	-	-	✓	-	✓	-	-	-	-	-	-	-
Bernard <i>et al.</i> , 2019	-	-	✓	✓	✓	✓	-	-	-	-	-	-	-
<b>TOTAL (30)</b>	<b>12</b>	<b>9</b>	<b>26</b>	<b>28</b>	<b>9</b>	<b>10</b>	<b>14</b>	<b>3</b>	<b>6</b>	<b>19</b>	<b>6</b>	<b>14</b>	<b>3</b>

Generally, both the visiting frequency and relative abundance represent occupancy frequency of a mammal species [7, 10, 25, & 36], therefore reflects the viewing success of the given species by tourists at a mineral lick and under a particular time [4, 48, 49]. Then, group size and visiting duration of the given species can be varied across different licks and times, where the largest group size and longest duration are expected to be sighted at the lick during peak hour or season [16, 25, 39]. Moreover, species diversity is often employed to represent relative variation of mammal species that can be encountered at a mineral lick and under a certain time [6, 10, 34].

The recreational importance of a mammal species to tourists is reflected by its behavioural, morphological and identity traits [4]. Geophagic behaviour exhibited by mammal individuals at the mineral licks is a form of behavioural uniqueness [49]. Then, the threatened, rare,

large-sized, and endemic ungulate and predator species with unique physical appearances are highly desired to be viewed by tourists during mammal-watching as well. This is because given species demonstrate extraordinary morphological (body size and physical uniqueness) and identity (rarity, endemism, and feeding guild) attributes [4, 28, 42]. In other words, species diversity represents relative variation of viewable mammal species. Then, visiting frequency and relative abundance represent the sighting probability, whereas the visiting duration and group size represent the individual number and duration respectively, for a certain mammal species that can be viewable at a particular mineral lick and time. Table 3 displays functions of respective keystone parameters in representing mammalian availability as tourism supply at a mineral lick.

Table 3: Functions of six parameters in representing mammalian availability for salt-lick tourism (Adapted from: Reynolds & Braithwaite [42]; Wolf & Croft [49]; Winterbach *et al.*, [48]; Arbieu *et al.* [4], and; Kubo *et al.*, [28]).

Parameter	Definition and Function
<b>Quantitative-Based</b>	
Visiting Frequency/ Relative Abundance	Sighting probability of a mammal species by tourists at a mineral lick and under a specific time or season.
Visiting Duration	Average duration of a mammal species that can be sighted by tourists at a mineral lick and under a specific time or season.
Group Size	Average number of individual for a mammal species that can be sighted by tourists at a mineral lick and under a specific time or season.
Species Diversity	Relative variation of mammal species that can be sighted by tourists at a mineral lick and under a specific time or season.
<b>Qualitative-Based</b>	
	Criteria that define the recreational importance of a mammal species, as perceived by tourists during mammal-watching at a mineral lick, in terms of:
Species Trait	<p>A) <b>Behavioural Pattern</b> – Natural behaviours demonstrated by a mammal individual, which is sighted by tourists at a mineral lick (e.g.: geophagic behaviour, drinking spring water, courtship ritual and foraging).</p> <p>B) <b>Mammal Morphology</b> – Body size (large, medium &amp; small) and physical uniqueness (e.g.: have flanged face, scaled body, antler, tusk, or horn) of a mammal individual that is viewed by tourists at a mineral lick</p> <p>C) <b>Identity Trait</b> – Rarity (reflected by conservation status), endemism, and feeding guild (tropic position) of a mammal species that is encountered or viewed by tourists at a mineral lick.</p>

### Explanatory Factors with Influences towards Mammalian Availability at Mineral Licks

Based on Table 2, a total of seven explanatory variables were often applied by the selected past studies, and then most of these past studies included two out of the seven explanatory variables. Time of day was employed most frequently (63.3 % or 19 past studies), followed by lick properties and season equally (14 or 46.7 % past studies

respectively). The food source and nutritional value, as well as surrounding environment, were equally seldom being used (3 or 1.0 % past studies respectively), and then both human presence and predation pressure, and weather condition were equally used only by 6 or 20.0 % review materials, in this field of study. Relationship between the seven mentioned explanatory variables and mammalian availability as salt-lick tourism supply can be illustrated as shown in below Figure 1.

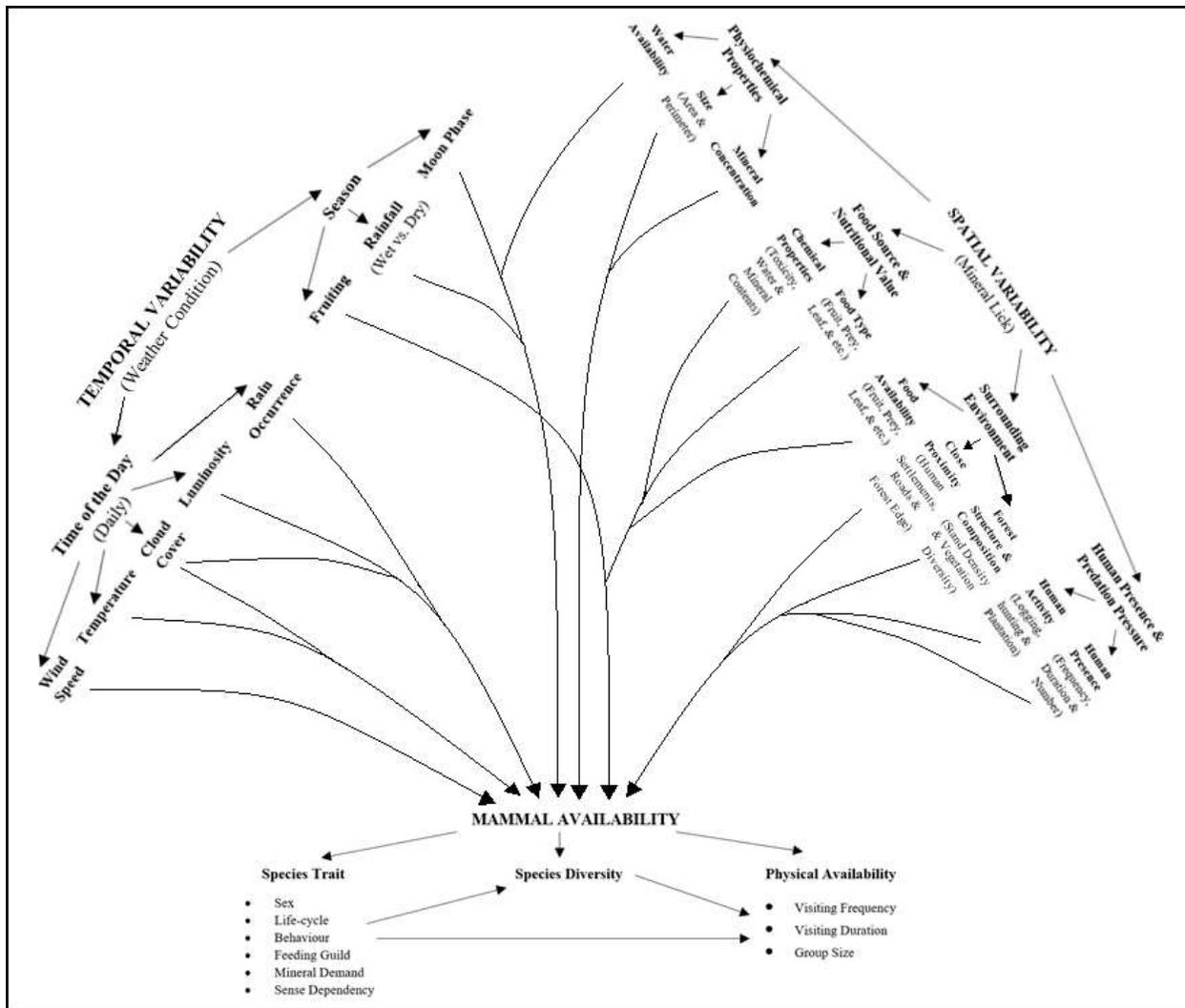


Figure 1: Relationship between different explanatory variables with mammalian availability for salt-lick tourism.

### Physiochemical Properties of Mineral Licks

Every mammal species have different mineral demands, and then each mineral lick provides different minerals and in different concentrations. Therefore, mineral licks that can supply various concentrated minerals are likely to be highly visited by a wide range of mammal species [34, 38]. At the tropical forest of Borneo, both Bearded Pig (*Sus barbatus*) and Sambar Deer (*Cervus unicolor*)

visited to sodium-rich licks frequently, which reflected their high dependencies over the licks for fulfilling their daily mineral demands [33, 34, 36]. Then, a large-sized lick can accommodate more wildlife individuals, hence can be visited by various mammal species and in large group at a time, and vice versa [5, 14, 29]. High clay mineral availability (e.g.: kaolinite) can drive particular mammal species to visit a mineral lick more frequently as well, for bone growth, maintaining skin integrity and

gastrointestinal disease prevention [5, 17, 36, & 46]. In other words, dependency of a mammal species towards mineral licks influence its visiting frequency to the lick, which can ultimately defines the diversity of mammal species that can be viewed at the given lick at a certain time or season.

### **Food Source and Nutritional Value**

Herbivorous-frugivorous mammals visited to a mineral lick more frequently when the consumed forages were insufficient in sodium and water contents [20, 35]. But then, high fruit availability may cause diet shifting from leaves to fruits, which can reduce consumption of toxic leaf and subsequently reduce the visiting frequencies of given species to the licks for neutralizing body toxicity through mineral consumption [26, 30]. On the contrary, predator species can obtain sufficient minerals through consuming other wildlife individuals, thus these species visit to the licks mostly for prey-hunting [11, 34]. Then, an increasing in prey abundance may also attract higher visitations of predators to given licks [18]. Long story short, mammal individuals with fibre-based diets may visit to the licks more frequently as adaptive responses to body toxicity, water and nutrient imbalances [5, 46], which can be influenced by the availability of fruit at a certain time or season [21]. Then again, further research is required to confirm the effect of fruit availability and prey-predator relationship over mammalian availability at the licks in future.

### **Temporal Variability in Weather Condition**

Weather condition has direct effect towards mammalian availability at a mineral lick [13, 20, 24, 30, & 44]. Diel activity patterns of mammals in visiting to mineral licks are different between species, hence group size, visiting frequency and duration are applied to categorize them as cathemeral (active throughout the day), diurnal (7:00 a.m. to 5:00 p.m.), crepuscular (5:00 p.m. to 7:00 p.m. and 5:00 a.m. to 7:00 a.m.), or nocturnal (7:00 p.m. to 5:00 a.m) species [21, 22, 33, & 35]. Then, sensitivity of a mammal individual towards the temporal change in weather condition is dependent towards its sex, species, age, and sense dependency, which can ultimately affect mammalian availability for a particular time or season at a mineral lick [24, 35]. In other words, the temporal variability in weather condition, especially in terms of ambient temperature, rainfall, cloud cover, luminosity, and wind speed, can trigger spatial-temporal variability in mammalian availability at a mineral lick.

Rainfall is frequently employed in determining the seasonal climate condition of an area, because it defines the local water availability and subsequently affects the behaviours and responses of local mammal community. As an example, female Sambar Deer visited to the licks

significantly more frequently during wet season than at dry season [35], while female Banteng (*Bos javanicus*) visited to the licks significantly more frequently during dry season than at wet season [24]. This is because wet season is known as the peak birth season, where mother individuals require high and frequent calcium intake for milk production throughout given time period [19, 27]. Other than that, forages contained high amount of water during wet season, and then high consumption of water-rich forages could stimulate urination and caused body mineral loss frequently [43]. Actually, both phenomena could lead to mineral deficiency, henceforth ultimately increase mammalian visitations to the licks throughout wet season. On the contrary, mammal individuals may visit to mineral licks with permanent spring water more frequently for drinking water during dry season [18]. This phenomenon can be a possible explanation to the significantly high visiting frequency of female Banteng herd to mineral licks during dry season [24], although further research is required to scientifically proof this hypothesis in future. In a nutshell, seasonal rainfall has prominent effect to mammalian availability at the licks.

Impacts of daily rainfall, cloud cover, luminosity, and ambient temperature over mammalian availability at mineral lick were determined to be insignificant [20, 24, 44], although viewing success of diurnal mammals at the licks were higher during middays with zero cloud and maximal ambient temperature [30]. Then, influence of moon phase (nocturnal luminosity) onto mammalian availability at the lick has yet been investigated by past researchers at the mean time. Nocturnal luminosity is at maximum during full moon, and then decreased along with the change of moon phase to new moon, and vice versa. High nocturnal luminosity can benefit the visual-dependent mammal species (omnivores, herbivores and frugivores) in detecting approaching predators, foraging and travelling, hence restricting movements of predator species, especially at open areas such as mineral licks, and vice versa [31, 40, 45]. At the same time, rain and high wind occurrences can mask out olfactory, hearing and visual senses, hence both prey and predator species may avoid visiting to mineral licks and exposing their presences towards one another there accidentally under such weather [30, 44, 49].

In summary, seasonal rainfall and wind speed are determined with prominent effects towards mammalian availability at a mineral lick, while nocturnal luminosity is suitable for assessing seasonal variability in nocturnal mammalian availability at the lick. Due to insufficient studies on the applications of cloud cover, moon phase and ambient temperature, thus influences of these three parameters over mammalian availability at the licks are included as research gaps for this field of study.

## **Human Disturbance and Surrounding Environment**

Human presence can trigger flight-and-fight response of mammals, where mammal individuals will escape when human individuals have entered their flush distances at a given location [9]. Because of that, frequent human visitation can result in reducing visiting frequencies of mammal species that are intolerant to human presence at mineral licks [12, 33]. At the same time, particular mammal individuals may shift towards nocturnality or visit to other mineral licks, as their avoidance responses over human visitations and activities conducted at the licks [9, 21]. Therefore, mineral licks that are situated close to roads, human settlements and forest edges are likely be avoided by disturbance-sensitive species and visited by disturbance-tolerant species, and then these mammal individuals are exposed to high risks of being hunted or poached [12, 20, 44].

Additionally, degraded forest habitats have limited tree stands and vegetation diversity that serve as both food sources and shelters to various species and a large number of herbivorous-frugivorous mammals [47]. Due to that, only limited individual and species can continue living at given habitats, which can gradually reduce the diversity and individual number of mammal to the local mineral licks [24]. However, Matsubayashi *et al.* [33] reported that the visiting frequency of Orang-utan (*Pongo pygmaeus*) to mineral licks was not impacted by surrounding forest condition, but the close proximity of the licks to roads. This is because different mammal species may respond varyingly towards the surrounding habitat condition of a mineral lick [24, 33, 47]. In other words, mammalian availability can be affected by close proximity to disturbed environment, surrounding forest composition and structure, visiting frequency of human, and intensity of human disturbance done to the mineral licks [9, 12, 24, & 33].

## **CONCLUSION**

Mineral lick is vital to the well-being of wildlife, thus certain mammal individuals willing to visit to the open environment of mineral licks for replenishing their body minerals, while exposing themselves to predation risks. Because of that, mineral licks can serve as venues for tourists to view free-roaming mammal individuals at a natural forest setting. Generally, species traits, species diversity and physical availability are used to represent the duration, intensity, authenticity, uniqueness, species popularity and status of mammals that can be sighted by tourists at a mineral lick. Furthermore, availability of a mammal species for salt-lick tourism depends on both onsite and surrounding environmental, anthropogenic and bio-physiochemical conditions of the given lick.

Presently, human presence and predation pressure, seasonal rainfall, surrounding habitat condition, mineral

concentration, food source and nutrient value, and daily wind speed are determined with significant influences towards mammalian availability at a mineral lick. Daily rainfall, prey-predator availability relationship, fruit and water availabilities, size of mineral lick, and the moon phase have potential effects to mammalian availability at the licks, unlike cloud cover and ambient temperature with insignificant impacts onto the given matter. Hence, it is vital to conduct further research on these variables with potential effects towards mammalian availability at the licks, from both ecological and salt-lick tourism perspectives, to fill up these research gaps.

Furthermore, perceptions of tourists towards the sighting of geophagic behaviours exhibited by mammal individuals at mineral licks is required to be determined scientifically to further close up the research gap of this field of study. Additionally, further research is required to determine the carrying capacity of tourist for salt-lick tourism in future. In conclusion, this paper review has achieved its objective in addressing the research gaps of this field of study, through both ecological and salt-lick tourism perspectives.

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