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The ecological characteristics of mineral lick associated with animals in Belantikan Hulu Area, Central Kalimantan, Indonesia

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Abstract

Mineral licks are areas rich in essential minerals where wildlife such as mammals and birds frequent to lick or eat soil (geophagy). Mineral licks are a beneficial site for animals since the behavior increases mineral intake and emulsify toxins that enter the digestive system. The Belantikan Hulu area is known to have mineral licks in its forest area, two of which are frequently visited by various animals. The purpose of this research is to provide an overview of the ecological characteristics of two different mineral licks, as well as to identify the diversity of animals that use the area. The study was carried out in the Belantikan Hulu area, using the capture and recapture method as well as the laboratory process to identify minerals in mineral licks. The results of the sample analysis revealed that the mineral licks in the two areas contain Na, K, Ca, and Mg. When compared to other locations, the Penggaraman area has the highest concentration of three minerals. During the research period, 2.133 independent photos were captured at two mineral lick sites. A total of 16 animal species were recorded, including 10 species of mammals and six species of birds. There is a symbiotic interaction of mutualism between mammals and birds at the mineral lick, as well as a sympathetic interaction in primates. The ecological characteristics of mineral licks, such as minerals and distance from human activity, affect wildlife visits to mineral lick sites.

Keywords: Belantikan Hulu, Camera trap, Geophagy, Mineral lick

Introduction

The Belantikan Hulu area is included in the landscape of the Schwaner mountains, which is a high priority area for conservation efforts of the Bornean orangutan (*Pongo pygmaeus wurmbii*) and the bull species (*Bos javanicus lowii*) in Borneo[1,2]. The Belantikan Hulu area has the status of a limited production forest (HPT) which is a habitat for the largest orangutan population outside the conservation area. Its forest area is known to have mineral lick sites. According to community information, two of them, Penggaraman and Pasiran mineral licks are frequently visited by various species of wildlife[3,4].

A mineral lick is a unique site in various types of habitats with rich natural minerals that animals frequently visit to lick essential mineral nutrients from a deposit salts or eat soil. Geophagy is the term used to describe animal soil-eating behavior. The benefits of geophagic behavior are still being debated, but recent studies have shown that the soil consumed provides sodium and other minerals to help absorb toxins contained in the food they consume or emulsify toxins that enter the digestive system[5–7]. The lack of minerals in parts of trees eaten by animals, particularly herbivorous ones, causes them to engage in geophagy in forests or specific locations[8].

Mammals such as ungulates, primates, and rodentia, as well as some bird species, are known to engage in geophagy[9,10]. The mineral element is one of the components that are indispensable for living beings in addition to carbohydrates, fats, proteins and vitamins[11]. Minerals are required by all living things, including animals, for physiological processes. Thus, mineral is an essential element. Any mineral deficiency can cause abnormalities in physiological processes[12–15]. Mineral lick contains sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and a variety of other minerals that are required for osmoregulation, bone growth, and muscle[16]. Even though the mineral licks are relatively far away, the site attracts animals to come and do geophagy. Despite being a small site in a vast forest landscape, it is a biodiversity hotspot in the area[17.18].

Mineral lick sites are important factors in ensuring the availability of essential minerals for forest animals. According to some studies, it is also used to obtain minerals by endangered species such as the Bornean orangutan (*Pongo pygmaeus*), pangolin (*Manis javanica*), Asian elephant (*Elephas maximus*), banteng (*Bos javanicus lowi*), and sambar deer (*Rusa unicolor*). Wildlife footprints are also frequently seen at mineral lick sites, indicating the importance of mineral lick use for animals[18–20].

Animals have been observed licking or eating soil at the mineral lick site in the Belantikan Hulu area, but there is no documented data on the ecological characteristics of the mineral lick site and its relationship with the mineral needs of animals. This study aims is to provide an overview of the ecological characteristics of two different mineral lick sites, as well as to determine the diversity of animals that engage with the two mineral lick sites.

Materials and methods

Study area

This research was carried out in July 2017-March 2018 followed by November 2020 and December 2021 in the Belantikan Hulu Area. Administratively, the Penggaraman mineral lick (01°34'11.654''S, 111°21'50.148''E) and Pasiran mineral lick (01°33'11.07''S, 111°21'38.545''E) are located in Kahingai Village and Nanga Matu Village, Belantikan Raya District, Lamandau Regency, Central Kalimantan Province. Soil pH meters, plastic clips, a Global Positioning System (GPS) device, camera traps, camera viewers, bear boxes, memory cards, batteries, sling ropes, padlocks, shovels, research location maps, and animal identification manuals were used in the study.

Procedures

Ecological characteristics of mineral lick

Observations were made by looking at the main source points of mineral licks, altitude, soil color, soil pH, and mineral content to identify the ecological characteristics of mineral licks. The pH meter was calibrated before being plugged into the soil layer in the mineral lick area, and the results were displayed numerically on the pH meter screen and recorded. The next step is to collect soil samples to determine the mineral content at the mineral lick location. Soil samples were collected with a shovel from mineral lick sources, stored in plastic clips, dried in plastic boxes, and weighed 500 grams each for mineral content analysis. Several ecological characteristics were measured at the control sites (500 m of both mineral licks) as comparison data.

Capture-recapture using camera trap (CT)

In general, the Capture-Recapture method is used to determine the presence of animals and has become an increasingly popular tool for studying the presence of animal species as well as identifying specific individuals. Currently, the camera trap has made it easier to monitor wildlife at mineral lick sites[21,22]. Animals were observed by setting up a camera trap and directing it to the observed mineral lick source. CTs were installed at the Penggaraman and Pasiran mineral licks. Camera traps were installed on both mineral licks to see the diversity of animals enggaged with mineral licks in Belantikan Hulu Area. The camera trap is attached to the mineral lick 24 hours a day, taking three series of photos with no intervals between shutters, in a fixed position. Within a certain period, the CT battery and memory card are replaced. Camera traps are mounted on tree trunks 100-150 cm above the ground. No food bait was used in this study. Each photo is identified as a species as well as an individual, and if the photo quality is poor, it is captioned as an unidentified image (unidentified/ unknown picture).

Data analysis

The mineral content of soil samples at and outside the salt lick were identified at the Laboratory of Soil, Plants, Fertilizer, Water, Agricultural Research and Development Agency, Cimanggu Bogor. The data was analyzed descriptively. The capture images are renamed using the Picture Information Extractor software. Each captured species was classified as: (1) consecutive photographs of different individuals of the same or different species, (2) consecutive photographs of individuals of the same species taken more than 0.5 hours apart, (3) non-consecutive photos of individuals of the same species[23].

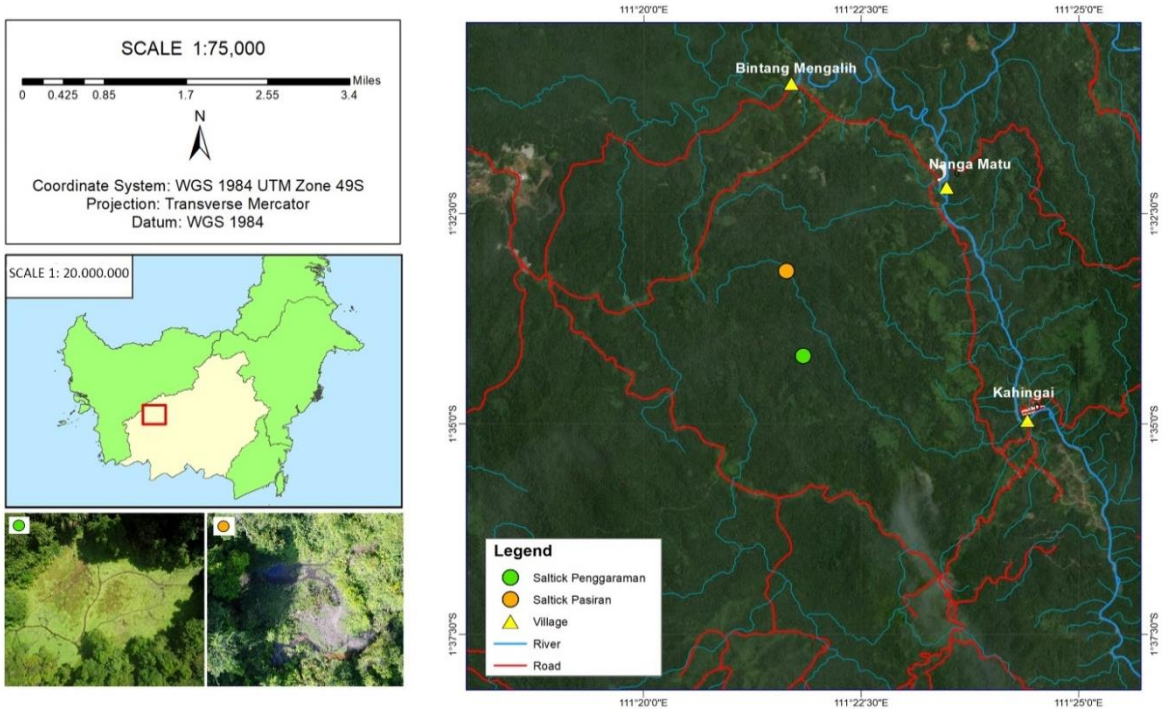

Figure 1. Location of Penggaraman and Pasiran Mineral Lick, Belantikan Hulu Area, Central Kalimantan

Results

Ecological characteristics of mineral lick

Mineral licks in Belantikan Hulu are situated at an altitude of 60-70 asl. with 80% more sand texture at the mineral lick site than at the control location, which is dominated by clay texture (40-50%). The mineral lick appears dark gray, as opposed to the control location, which appears brown. Mineral content analysis revealed that soil samples from the mineral lick site contained higher concentrations of Natrium (Na) and Calcium (Ca) minerals than soil samples from the second location. The concentration of Na minerals in both mineral licks is one-three times higher than the control, while the concentration of Ca minerals in both mineral licks is 15-50 times higher than the two controls. Meanwhile, for the concentration of minerals K, Mg, and soil pH, there are variations in all locations. In comparison to other locations, Penggaraman has the highest concentration of three minerals (**Table 1**).

Table 1. Ecological characteristics of the mineral lick in Belantikan Hulu Area

Location	Mineral concentration (mg/kg)				Texture (%)			Color	pH	Altitude (masl)
	Na	Ca	K	Mg	Sand	Dust	Clay			
Penggaraman	500	900	300	1.000	83	3	8	Dark gray	7.1	70
Pasiran	165	245	165	276	84	5	11	Dark gray	6.8	60
Control 1	141	14	365	286	38	17	45	Light brown	6.9	74
Control 2	99	16	376	278	27	26	47	Dark Brown	6.8	62

Note: (Control 1) sampling of ±500 m from Penggaraman Mineral Lick; (Control 2) sampling of ±500 m from Pasiran Mineral Lick

Mineral licks in the area Belantikan Hulu is located close to human activities, as in Pasiran, 1.94 kilometers from the main road and 3.87 kilometers from the village, whereas Penggaraman is located quite far from human activities, 2.90 kilometers from the main road and 4.80 kilometers from the village.

Diversity of Animals Enggaged with Mineral Licks in Belantikan Hulu Area

During the study period (561 camera active days), 2.133 independent photos were collected at two mineral lick sites. In this study, 16 species of animals were recorded, including 10 species of mammals and six species of birds. Among these species are one critically endangered species (CR), the Bornean orangutan (*Pongo pygmaeus* wurmbii), four endangered species (EN), the banteng (*Bos javanicus* lowii), the long-tailed macaque (*Macaca fasicularis*), the southtern pig-tailed macaque (*Macaca nemestrina*), and the storm's stork (*Ciconia stormi*), and five vulnerable species (VU) that are classified by The IUCN Red List.

In terms of edemicity, there are five species of animals endemic to Kalimantan recorded visiting the mineral lick site (**Table 2**). Grouped animals utilized mineral licks higher (55%) than solitary animals (45%). Long-tailed macaque (87.10%), red langur (83.16%), and white-fronted langur (68.64%) are mammals that have a maximum group visit compared to other mammals. Meanwhile, there is only one species of bird; slender-billed crows visit the maximum (100%) to mineral licks in groups.

Overall, Penggaraman took 1,727 independent photos of 14 different animal species, while Pasirann captured 406 independent photos of 10 different animal species. From all independent photos taken in Penggaraman, banteng was recorded the most (41.34%). Deer was the most photographed (63.79%) in Pasiran.

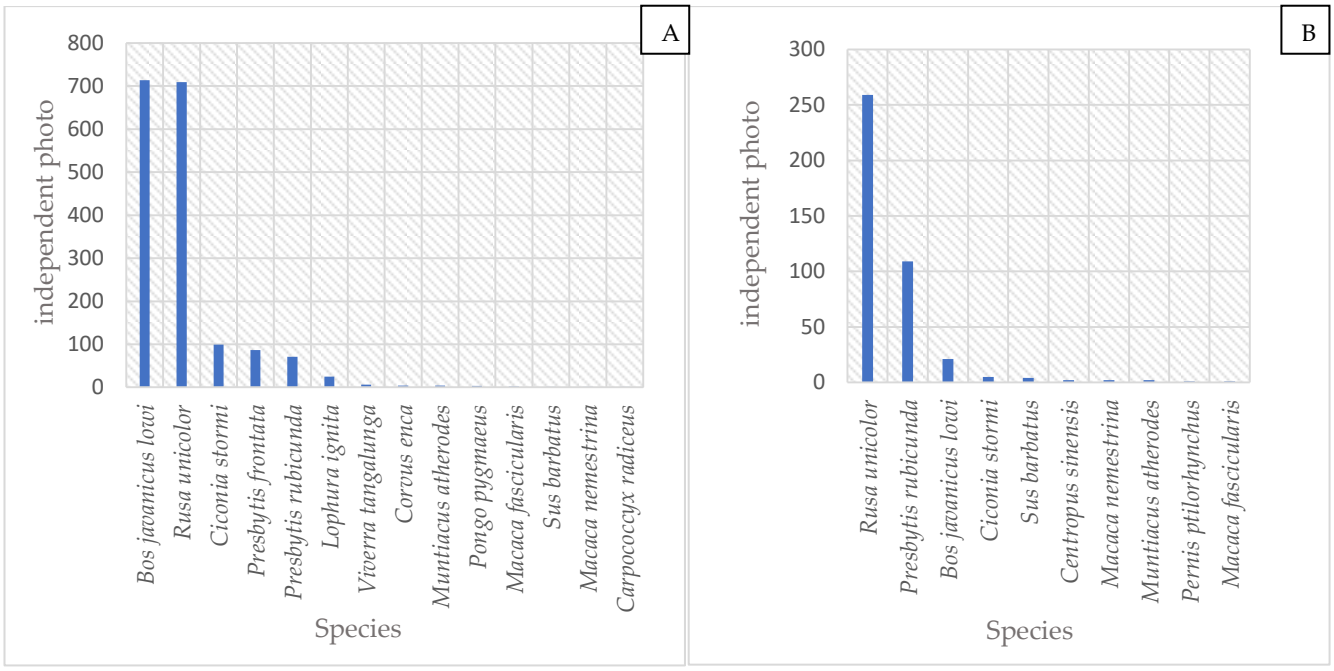

Figure 2. Number of independent photo animal in a) Penggaraman Mineral Lick, b) Pasiran Mineral Lick.

Discussion

Ecological characteristics of mineral lick

The Belantikan Hulu area is located in the Arabela landscape (Arut-Belantikan Landscape), which is part of the Schwaner Mountains and stretches between the Upper West Kotawaringin Regency and the Upper Lamandau Regency in Central Kalimantan.The mineral lick location in the Belantikan

Hulu area is part of the Limited Production Forest (HPT) area, under the Forest Utilization Business Permit (PBPH) operated by a private sector company. Mineral lick locations in the Upper Belantikan area are part of the Limited Production Forest (HPT) area, which is managed by a private company under the Forest Utilization Business Permit (PBPH). The Belantikan Hulu's forested area is dominated by Dipterocarpaceae tree stands such as *Shorea* sp., *Dipterocarpus fagineus*, *Shorea laevis*, and *Vatica resak*. In some locations ironwood trees (*Eusideroxylon zwageri*) are still commonly found, and lick minerals are found in this forest area[24].

Table 2. Diversity of animals enggaged with mineral licks in Belantikan Hulu Area

Order	Family	Species (scientific name)	Size Group (%)		IUCN Redlist
			Solitary	Group	
Mammal					
Primates	Cercopithecidae	Long-tailed macaque (*Macaca fascicularis*)	12.90	87.10	EN
		Southern pig-tailed macaque (*Macaca nemestrina*)	100.00	0.00	EN
		Red langur (*Presbytis rubicunda*)*	16.84	83.16	VU
		White-fronted langur (*Presbytis frontata*)*	31.36	68.64	VU
	Hominidae	Bornean orangutan (*Pongo pygmaeus wurmbii*)*	66.67	33.33	CR
Carnivores	Viverridae	Malay civet (*Viverra tangalunga*)	100.00	0.00	LC
Cetartiodactyla	Suidae	Bearded pig (*Sus barbatus*)	100.00	0.00	VU
	Cervidae	Bornean yellow muntjac (*Muntiacus atherodes*)*	42.86	57.14	NT
		Sambar deer (*Rusa unicolor*)	55,25	44.75	VU
	Bovidae	Banteng (*Boss javanicus lowi*)	45.87	54.13	EN
Bird					
Accipitriformes	Accipitridae	Oriental honey buzzard (*Pernish ptilorhynchus*)	100.00	0.00	LC
Ciconiiformes	Ciconiidae	Storm's stork (*Ciconia stormi*)	54.79	45.21	EN
Passeriformes	Corvidae	Slender-billed crow (*Corvus enca*)	0.00	100.00	LC
Cuculiformes	Cuculidae	Bornean ground cuckoo (*Carpococcyx radiceus*)*	100.00	0.00	NT
Cuculiformes	Cuculidae	Greater coucal (*Centropus sinensis*)	100.00	0.00	LC
Galliformes	Phasianidae	Bornean crested fireback (*Lophura ignita*)	71.17	28.83	VU

Note: LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; *endemic.

Mineral licks are specific locations in the forest that are rich in natural minerals and are frequently visited by animals to lick or eat essential minerals in soil (geophagy). Geophagic behavior has been observed in many different parts of the world. Mammals and birds are examples of animals that visit mineral licks on a regular basis to engage in geophagic activities[25]. The mineral content of the soil in the mineral lick area is distinguished by an increase in the composition and amount of minerals such as sodium (Na), calcium (Ca), potassium (K), and magnesium (Mg), and some others. [16]. In the tropics, sodium is the mineral most sought after by animals[26]. Mineral-licking is essential for herbivorous and frugivorous mammals. Many mammals, particularly herbivorous mammals, engage in geophagic behavior to supplement their mineral intake[25–27]. Herbivorous mammals in tropical rainforests require more Na intake because plants in tropical rain forest areas are low in Na.

Furthermore, the essential minerals in mineral lick can aid digestion and eliminate toxins that enter the digestive system[30]. Birds also carry out geophagic activities; the most common information of birds carrying out geophagic activities is to ingest coarse soil particles. Birds engage in geophagy as well; the most common example of birds engaging in geophagy is the swallowing of coarse soil particles. Birds do not have teeth like mammals. Birds will consume food, which is then temporarily stored in the cache[31]. The process of birds eating soil is also related to sodium concentration for both toxin adsorption and supplementation. For example, in the Amazon, birds from the Psittacidae family consume sodium-rich soil to absorb alkaloid toxins. Clay is important for geophagic animals because minerals in the soil are most easily bound to alkaloid toxins[5,32,33]. The sodium concentration is generally higher than at the control site[34]. This confirms up the findings of a mineral content analysis of the soil at the study site, where the concentration of Na minerals in both lick minerals was higher than the control. The minerals of each mineral lick vary, but there is no consistent pattern in the average mineral component content. Although there is strong evidence that the sodium in the soil is the cause of mammals geophagic activities, there are mineral licks with less Na concentration but a higher Ca concentration, which serves as bone strengthening and overall wellness in animals[5.32].

Sumatran elephants in the Way Kambas National Park area engage in geophagic activities as part of the body's metabolic process to facilitate their food digestion. Sumatran elephants require mineral intake to maintain their immune system and to strengthen their bones, teeth, and tusks [33.34]. As a result, the presence of lick minerals in certain areas can provide sufficient minerals to animals in the area, as well as maintain the health of animal populations and serve as a basis for population persistence in the area[10].

Animals enggaged with mineral licks in Belantikan Hulu Area

Nine of the ten mammal species that visited mineral-licks were recorded to engage in geophagic activity; the malayan civet was the only mammal species that was not recorded to engage in geophagic activity (carnivore). The Malayan civet was only passing through mineral licks, but it is possible that these mammals foraged around mineral licks because this location is home to a variety of invertebrates (dragonflies and butterflies) and small vertebrates (frogs). The Malayan civet is a terrestrial animal that feeds on invertebrates and small vertebrates on the forest floor[37]. Other studies have found that carnivorous species recorded in mineral licks include civets (Viverridae) and mongoose (Herpestidae), which are unlikely to prey on terrestrial mammal species that are much larger in size, such as sambar deer, banteng, and muntjac[38]. Large carnivorous species such as the clouded leopard (*Neofelis nebulosa*) were not detected in the two lick minerals. This contrasts with research conducted in Malaysia's Sabah region, which discovered the presence of moderate to large carnivores in mineral licks. Animals that visited the lick mineral were mostly herbivorous, though carnivorous species such as short-tailed mongoose, malayan civet, and clouded leopards were observed in the mineral licks and surrounding area. Mineral licks are mostly used by big terrestrial mammals as corridors, yet carnivorous may have

come here to hunt for prey[18].

The bornean crested fireback (*Lophura ignita*) and the storm's stork (*Ciconia stormi*) were two of the six bird species found in the both mineral licks and recorded for geophagic activity. Previous studies found that birds from the family of Phasiniaidae, Columbidae, and Psitacidae lick minerals and consume sodium-rich soil to help absorb alkaloid toxins.[39,40] Crested firebacks are members of the Phasianidae family, which belongs to ground-living birds group. Storm's stork is another Ciconiidae species that has been observed to engage in geophagy. The slender-billed crow, Bornean ground cuckoo, greater coucal, and oriental honey buzzard were all captured on camera although not engaging in geophagy. The presence of the slender-billed crow and Bornean ground cuckoo is always accompanied by the presence of other animals such as the banteng and sambar deer. The slender-billed crows and sambar deer have a mutualistic symbiotic relationship, as do the Bornean ground cuckoo and the banteng (**Figure 3**). Slender-billed crows and bornean ground cuckoos perch on the bodie or head of banteng and deer and feed on fleas. This demonstrates that mineral-licks benefit not only herbivorous animals but also carnivorous and other animals that interact with geophagic animals. Meanwhile, the activity for the presence of oriental honey buzzard (*Pernis ptilorhynchus*) on the soil surface at the mineral lick location is unknown and requires more information.

Figure 3. Mutualistic symbiosis between crows and sambar deer (left) and ground cuckoo and banteng (right) in Penggaraman Mineral Lick.

Animals that lick minerals are classified according to their group size: solitary, two or more individuals (groups). In in Veun Sai-Siem Pang National Park, Cambodia, animals that lick minerals in groups have a higher percentage (62.60%) than soltary using[9]. Other studies have found that when primates visit mineral licks, they form larger groups because it is a high-risk area for predators, and larger groups can defend against such threats. Group use in primates has the highest percentage of mineral licks in the Belantikan Hulu area. Primates in groups are able to visit maximally, not only to get mineral intake but also as a place to mate[9]. Other studies have also reported that primates make larger groups when visiting mineral-licks because it is a high-risk location (predation) and larger groups can provide defense against such threats[25]. Larger groups are a strategy to reduce the risk of threats from predators. Species with larger groups may be able to dominate and be able to access mineral resources for a longer time or as a strategy to protect the herd against predators there were sympatric interactions between red langur and white-fronted langur in this study; both species shared mineral-lick locations and formed groups without conflict. This interaction could be a strategy to gain access to mineral resources for a longer period of time or to reduce the risk of predator threats (Figure 4). Only crows have

the highest frequency of group visits among birds. Others prefer to visit alone to access mineral-licks, though the Bornean crested fireback was occasionally seen in pairs.

Figure 4. Sympatric Interaction of Red Langur and White-fronted Langur in Penggaraman Mineral Lick

The camera trap analysis results show that the presence of species in Penggaraman mineral lick is higher than the presence of species in Pasiran mineral lick.This condition is inextricably linked to the mineral content of the soil in both sites. 11 of the 16 species recorded visited the mineral lick sites to lick or eat the soil (geophagy) to supplement mineral intake, particularly sodium. A mineral content analysis revealed that Penggaraman mineral lick has higher concentrations of sodium (Na), calcium (Ca), potassium (K), and magnesium (Mg). This enables the animals to prefer to Penggaramann mineral lick for geophagic activities.

The distance to settlements and roads is another factor that influences the presence of animals in both mineral licks. The presence of humans and the types of disturbances at HPT locations increase with changes in logging activities carried out each year. Logging will create access roads and encourage people to open fields for farming or hunting[41]. Continuous hunting has also resulted in a decrease in the presence of hunted animals in areas close to the village, so the community eventually expanded their hunting area[42,43]. One of the threats causing a decline in animals populations is hunting. Locals in Belantikan Hulu still hunt for food using snares and rifles. Logging activities can also be found in the vicinity of the mineral lick. Since the Pasiran mineral lick is closer to settlements and roads, the animals would prefer to visit Penggaraman mineral lick to be safer from disturbance or community activities. Mammals and birds is not found in the mineral lick adjacent to the access road because it is more easily accessible to hunters[29].

The ecological characteristics of each mineral lick, such as mineral content and distance from human activities, will determine animals visits for geophagic or other activities. The presence of different species that use mineral lick varies from one and another[28,44]. These differences reflect differences in mineral content between sites, differences in habitat preferences between species, or topographical features that make some mineral licks safer from predators/hunting threats[45,46].

Conclusions

Mineral content, altitude, soil pH, soil texture, color, and distance from human activities were used to analyze the ecological characteristics of a mineral lick. The mineral content analysis revealed that the mineral lick soil samples contained higher concentrations of Sodium (Na) and Calcium (Ca) minerals than the control locations. Penggaraman mineral lick is the prime location since it has the highest

concentrations of Na, Ca, and Mg minerals compared to other locations. There are 16 animal species recorded in both mineral licks, including mammals and birds. More animals are recorded at Penggaraman than at Pasiran mineral lick. Animal visits to mineral licks are determined by ecological characteristics of lick minerals such as mineral content and distance from human activities.

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Conflicts of Interest

There are not potential conflicts of interest.

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