The Diversity of Mammals in the Wehea-Kelay Landscape, East Kalimantan

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Abstract: **The Wehea-Kelay landscape is an area with a tropical rainforest ecosystem which is the habitat for various types of mammals. Ecologically, the existence of mammal species plays role in maintaining the balance of the forest ecosystem, thus the balance of a forest ecosystem can be measured by the level of species diversity. The aim of this study is to determine the diversity, conservation status, relative abundance of mammal species, and the sepan conditions in the Wehea-Kelay landscape. The research was conducted from January to June 2020. The data collection method was the direct observation, signs searching, camera traps, and data analysis. The results of this study are 12 species, 9 families, and 4 orders of mammals were found. Based on the conservation status, 6 species as protected animals, 1 species is critically endangered, and 2 species are in appendix I. Overall, the highest relative abundance of mammals based on the presence frequency of the camera traps is M. muntjak and the lowest is T. kanchil. The species of mammals found based on the encounter rate in the Wehea Protected Forest were more than PT. Gunung Gajah Abadi, and the highest abundance of mammals is 1.67±1.529 individuals/km in Wehea Protected Forest and 1.00±1.00 individuals/km in PT. Gunung Gajah Abadi of H. malayanus. The feeding class of mammals found consisted of 9 species of Omnivores and 3 species of Herbivores. The sepan area in the Wehea Protected Forest is an area that must be conserved because it is a source of minerals for mammals.**

Keywords: **diversity, camera trap, mammals, sepan area, wehea-kelay landscape.**

I. INTRODUCTION

Etymologically, the landscape is a heterogeneous land area with a width of several kilometers which consists of a set of stands or interacting ecosystems that is repeated in a similar form (Forman & Godron, 1981). Understand that the land can not be conserved separately, a landscape approach offers a process to find a balance between conservation, use of natural resources, and improving human welfare by implementing sustainable agriculture, forestry production, and conservation of natural resources.

The Wehea-Kelay landscape is one of the areas with a tropical rain forest ecosystem, as a representation of lowland and highland forests. Its existence has an essential value as a source of clean air and a source of water for the Wahau River, Kelay River, and Telen River that are beneficial to the surrounding humans. The Wehea-Kelay landscape is also a habitat for around 1,282 individual Bornean Orangutans, 507 other wildlife species, and 713 plant species (Atmoko et al.,

2018). With an area of about 532,143 ha, the Wehea Kelay landscape has several area functions, including production forest, limited production forest, Wehea Protection Forest, and oil palm concessions in other use areas.

Specifically, the Wehea-Kelay landscape has a diversity of fauna species from various taxa. The number of orders of mammals found in the Wehea-Kelay landscape is 9 orders with the 3 most dominant orders being found, namely Primates, Carnivora, and Artiodactyla. Primates have an important role in helping plant regeneration by spreading seeds in the forest. Meanwhile, Carnivores have a role in maintaining the balance of herbivores and other small mammals by controlling the herbivorous mammal population in the forest (Atmoko, et al., 2018). Artiodactyla has an important role in fertilizing the soil and spreading grain (Mustari et al., 2015). The existence of mammals has contributed to the balance of the forest ecosystem and its surroundings. Mammals have ecological functions, namely as soil fertilizers, flower pollinators, seed dispersers, and biological pest control (Suyanto & Ubaidillah, 2002). Thus, the level of balance of an ecosystem can be measured by the level of species encounters found especially in mammals.

Data collection and information collection on the diversity of mammal species in the Wehea-Kelay landscape, East Kalimantan were carried out in 2017. The presence of Neofelis diardi and Helarctos malayanus as the top predators in the Wehea-Kelay landscape (Kelompok Kerja Pengelolaan KEE Bentang Alam Wehea Kelay, 2016). Thus, the presence and the responses of wild animals will depend on the degree of use by land-based enterprises in the landscape. This study aims to determine the diversity, conservation status, relative abundance of mammal species, and the sepan conditions of the Wehea-Kelay landscape that can be used as indicators in this area management strategy in the future.

II. METHOD

A. Study Site

This research was conducted from January to June 2020 in the Wehea-Kelay landscape in the natural forest of PT. Gunung Gajah Abadi and Wehea Protected Forest (Fig. 1). Each observation block has an area of 5 x 5 km and 3 transects of observation with a length of ±1 km are placed randomly. This research was conducted in 3 stages, it was direct

observation and signs searching, camera trap installation, and data analysis.

Fig. 1 The research site that describes the location of the survey blocks in the Wehea-Kelay Landscape

B. Data Collection

1) Direct Obesrvation and Signs Searching

Direct observation and search for signs left by mammals (signs searching) were carried out on a predetermined transect. It was repeated once on each transect. In direct observation, data collection is carried out on the type of species of the object, the time the object was observed, the location where the object was found, and photos for each direct encounter with the object. In the search for signs, data is collected on the type of species that left the mark, the time the sign was observed, the location where the sign was found, the condition of the sign, and a photo of each sign found. Some of the signs that were recorded were foot signs and scats.

2) Camera Trapping

Camera traps with sensors are installed at strategic places in each location. The camera is set and placed on a tree in 30-40 cm high, 3-4 meters from the center point of the active track where the animal will pass through the track. Then the camera is tested by researchers to ensure that the trigger system is working properly. The camera is operated 24 hours per day for 5 months at 2 predetermined stations.

C. Data Analysis

1) Data Tabulation

Data on mammal species that have been identified are tabulated based on family and species, datas' sources for each species found such as direct encounters, photo identification, food, foot signs, scat, and information on the status of mammal species identified at the study site based on IUCN, CITES, and Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.106/2018 concerning Protected Types of Plants and Animals.

2) Study of Species' Ecology

Data and ecological information of each species were obtained from various sources. Discussions was carried out per species or in general for each identified group of species.

3) Relative Abundance Based on the Frequency of Presence of Camera Traps

RAI_2 is the number of photos per 100 days of recording. The formula can be written as follows:

$$RAI_1 = \frac{\text{Total of Day Records}}{\text{Total of Independent photos per species}}$$

$$RAI_2 = \frac{1}{RAI_1} \times 100$$

O'Brien, et al. (2003) explains that independent photographs are defined as (1) sequential photographs of different individuals of the same or different species; (2) the sequential photographs of individuals of the same species taken more than 0.5 hours apart; (3) non-consecutive photographs of individuals of the same species.

4) Relative Abundance by Encounter Rate

The result of encounter rate (number of encounters/km) is obtained by counting the number of encounters with mammals (both visual and sign) along the transect, divided by the length of each transect (in km).

5) the Diet Class Grouping

The diets' class of each species of mammals found were determined based on the type of food that they eat (Carnivore, Omnivore, and Herbivore), the diets' class data was displayed in graphical form.

III. RESULTS AND DISCUSSION

A. Species of Mammals and the Conservation Status

Based on the results of the research that has been carried out, the species of mammals that have been successfully identified in the Wehea-Kelay Landscape and the conservation status can be seen in table 1.

B. The Relative Abundance of Mammals Based on the Frequency of Presence of Camera Traps

The relative abundance of mammal species based on the frequency of presence of camera traps in the Wehea-Kelay landscape can be seen in table 2.

Table 2. Relative abundance of mammal species based on the frequency of presence of camera traps in the Wehea-Kelay landscape

No	Species	Σ Independent Photos	RAI_1	RAI_2
1	H. brachyura	2	134,5	0,75
2	H. malayanus	2	134,5	0,75
3	M. flavigula	8	33,6	2,98
4	M. muntjak	14	19,2	5,21
5	M. nemestrina	3	89,7	1,12
6	P. canicrus	6	44,8	2,23
7	P. pygmaeus	2	134,5	0,75
8	P. rubicunda	5	53,8	1,86
9	R. unicolor	2	134,5	0,75
10	T. kanchil	1	269	0,37
Total			45	

From the results of camera traps, it has obtained 485 images from 269 cameras record day, which consists of 10 species and 7 families. The most often recorded species by camera traps is *M. muntjak* (with a recording frequency of 5.21 photos/100 days of recording). Meanwhile, *T. kanchil* has the lowest relative abundance (with a recording frequency of 0.37 photos/100 recording days).

C. Relative Abundance of Mammals Based on Encounter rate

Based on the results of direct encounters and signs of the presence of mammals, the encounter rate of mammal species found in the Wehea Protected Forest was more than the mammal species found in the forest area of PT. Gunung Gajah Abadi. There are 7 species found in the Wehea Protected Forest and 2 species found in PT. Gunung Gajah Abadi. Calculation of the relative abundance of the mammal species based on the encounter rate showed the highest relative abundance is *H. malayanus* with 1.67±1.529 individuals/km in the Wehea Protected Forest and 1.00±1.00 individuals/km in the PT. Gunung Gajah Abadi.

The relative abundance of mammal species based on the Encounter rate in the Wehea-Kelay landscape can be seen in table 3.

Table 3. The relative abundance of mammal species based on the Encounter rate in the Wehea-Kelay landscape

NO	Species	Wehea Protected Forest (individu/km)	PT. Gunung Gajah Abadi (Individu/km)
1	H. malayanus	1,67±1,529	1,00±1,00
2	M. muntjak	0,33±0.579	-
3	P. canicrus	1,00±1,73	-
4	P. hermaphroditus	0,33±0.579	-
5	P. pygmaeus	0,33±0.579	-
6	P. rubicunda	0,67±1,155	-
7	S. barbatus	0,33±0.579	0,33±0.579

Table 1. Species of mammals and the conservation status of species found in the Wehea-Kelay landscape

No	Order/ Family	Species	Source			The Conservation Status		
			CT	S	V	IUCN	CITES	National Regulation
Carnivora								
1	Mustelidae	*Martes flavigula*	X			LC	Ap. III	-
2	Ursidae	*Helarctos malayanus*	X	X		VU	Ap. I	√
3	Viverridae	*Paradoxurus hermaphroditus*			X	LC	Ap. III	-
Cetartiodactyla								
4	Tragulidae	*Tragulus kanchil*	X			LC	-	√
5	Cervidae	*Muntiacus muntjac*	X		X	LC	-`	√
6		*Rusa unicolor*	X			VU	-	√
7	Suidae	*Sus barbatus*		X		VU	-	-
Primate								
8	Cercopithecidae	*Macaca nemestrina*	X			EN	Ap. II	-
9		*Presbytis canicrus*	X		X	EN	-	-
10		*Presbytis rubicunda*	X		X	VU	Ap. II	√
11	Hominidae	*Pongo pygmaeus*	X	X		CR	Ap. I	√
Rodentia								
12	Hystricidae	*Hystrix brachyura*	X			LC	-	-
Ket.	LC VU EN CR √	= least concern = vulnerable = endangered = critically endangered = protected				CTS V Ap.	= camera trap = sign = visual = appendix	
	National Regulation	= Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.106/MENLHK/SETJEN/KUM.1/12/2018 concerning Protected Types of Plants and Animals.						

D. Species and Ecology of the Mammals

In the order Carnivora found *H. malayanus*, *M. flavigula*, and *P. hermaphroditus. H. malayanus* recorded at 17.11 and 22.08, it was seen eating around its' food resources on the tree. The characteristics of *H. malayanus* that can be seen in the picture are the rounded tips of the ears, black back hair, and yellowish hair color on the snout. *M. flavigula* has brown hair on the back and the color of the hair on the chest to the throat is pale to bright yellow. *M. flavigula* recorded at 05:23, 09:57, 14:53, 15:00, 15:23, 15:34, 15:50, 16:24, it was seen doing activities on the tree trunks. *P. hermaphroditus* has hair color from gray to cream, with three dark stripes on the back and black spots on the sides of the body. *P. hermaphroditus* was photographed directly at 17.30 while doing activities in the tree.

In the order Primates found *M. nemestrina, P. pygmaeus, P. canicrus*, and *P. rubicunda. M. nemestrina* has large muscles and a short tail that is coiled upwards and has grayish-brown hair. *M. nemestrina* was caught by camera traps at 08.17, 08.38, and 09.50 while walking on the ground. *P. pygmaeus* has orange hair on the body and no tail. *P. pygmaeus* was caught by camera traps at 08.58 and 13.41 while walking on the ground. In addition, *P. pygmaeus*'s bites were also found on a tree trunk. *P. canicrus* has a black face and a gray body. *P. canicrus* was caught on camera traps at 07.14, 08.06, 08.23, 10.48, 11.18, 11.27, and 11.57 in the Sepan area while it was drinking and sitting activities. *P. rubicunda* has a red dorsal hair color with a long tail. *P. rubicunda* was caught on camera traps at 08.06, 10.48, 11.18, 12.13, and 14.54, it was seen drinking and sitting in the sepan area.

In the order Cetartiodactyla, *M. muntjak, R. unicolor, T. kanchil*, and mud of *S. barbatus* were found. *M. muntjak* has brownish yellow hair that is paler on the abdomen and has a black line on the snout. It has two forked antler and one of the

branches is small, has a short and wide tail. *M. muntjak* was recorded at 05.53, 06.29, 07.03, 07.54, 08.58, 09.04, 09.38, 10.55, 12.02, 14.35, 17.26, 19.11, 19.28, 19.34, and 23.17 during they were eating and doing mobility activities. *R. unicolor* in adult male individuals has branched horns, dark brown hair, darker belly color, has wide ears, long tail, and black color. *R. unicolor* was caught by camera traps at 17.33 and 21.30 while it was drinking in the Sepan area. *S. barbatus* was identified from its wallowing site. During observation, *S. barbatus* was seen around the mud during their mobility activities. *T. kanchil*'s body size is relatively small with a characteristic brown line around the neck, reddish-brown hair color on the back surface, and white underside. *T. kanchil* was recorded at 03.06 while doing mobility activity.

In the order Rodentia, *H. brachyura* was found with the characteristics of having long spines on the black and white body surface, long, stiff and cylindrical spines on the back of the neck that can be raised into a short crest with mostly white with dark lines. *H. brachyura* was caught on a camera trap at 00.18 while doing mobility on the ground.
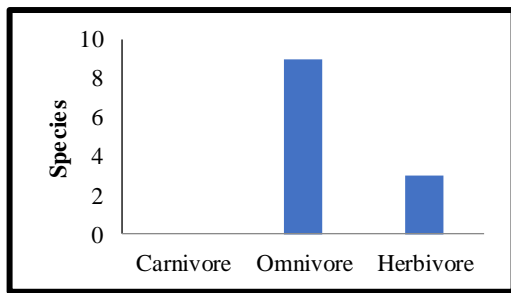
E. The Class of Diet

Fig. 2 Overview of the Mammal Diet Class in the Wehea-Kelay Landscape

There were only two dietary classes of mammals identified during the study, they were Herbivores and Omnivores (Fig. 2). 9 species of mammals are omnivores and 3 species of mammals are herbivores. In this study, no mammals were found that belonged to the Carnivorous diet class.

F. Sepan Area

In this study, observations were also made in the sepan area (Fig. 3). Based on the results of camera traps that were installed in the sepan area, it was observed that 5 species of mammals were active in the area, such as *R. unicolor, P. pygmaeus, M. muntjak, P. canicrus,* and *P. rubicunda*. The highest number of independent photos was found in *P. canicrus* with six independent photos, followed by *P. rubicunda* with five independent photos, while the lowest number of independent photos was found in *P. pygmaeus* with one independent photo.

For observations of mammalian activity in the Sepan, based on the results of the camera trap, it was observed that *P. pygmaeus* walked through the Sepan area, while the other four mammals were observed to regularly visit the Sepan area and

take advantage of the mineral water sources found in the Sepan area.

Fig. 3 Sepan Conditions in Wehea Protected Forest

G. Discussion

12 species of mammals found in Wehea Protected Forest and PT. Gunung Gajah Abadi, it was found that there are 3 types of mammals whose conservation status is protected according to IUCN, CITES, and Government Regulation of the Republic of Indonesia Number 106/2018, these species are *H. malayanus, P. rubicunda*, and *P. pygmaeus*. This indicates that Wehea Protected Forest area and PT. Gunung Gajah Abadi is an area with high conservation value and needs to be protected because in the area found protected species of mammals.

It was also found that *H. malayanus* which is the top predator that has a role to control the animal populations that have the potential to become pests in the food chain in Wehea-Kelay landscape ecosystem, the sustainability of these animals is very important. *P. rubicunda* and *P. pygmaeus* are primates that have a role as dispersers of seeds from the fruits they eat and spread through their feces. Mustari, et al. (2015) states that each mammal has different ecological roles and functions and interacts with each other in their habitats to their or different group. Ecologically, some of the roles of mammals are soil fertilizer, flower pollinator, seed dispersal, and pest control. So that the existence of mammals has an important role in the sustainability of a habitat.

From the camera trap results, a total of 485 images were obtained from 269 days of camera recording. *M. muntjak* was the mammal with the most records with a relative density of 5.21 photos/100 days recorded, while *T. kanchil* had the lowest relative density with a recording frequency of 0.37 photos/100 days recorded. *M. muntjak* was found in all locations in the protected forest where camera traps were installed, while *T. kanchil* was only found in one camera trap installation location.

The large number of *M. muntjak* individuals recorded by camera traps is thought to be due to the availability of food sources and the suitability of the habitat at that location, causing the population to be abundant. According to Mustari, et al. (2015), a large number of *M. muntjak* species in a habitat can be caused by the large number of young reeds and grass which are a source of food for *M. muntjak* in the habitat. In addition, habitat conditions also affect the abundance of

existing mammals. The existence of sources of food, water, shelter, and cover is very supportive of mammalian life.

The low number of *T. kanchil* was found to be caught by camera traps, presumably because *T. kanchil* is less adaptive to different habitats, in addition, because the animal is small so it is difficult to capture using the camera traps. The same thing was also reported by Sulistyadi (2016) in his research which stated that *T. kanchil* is a species that is sensitive to the changes in the habitat and limited resources so that its' distribution is less widespread than the adaptive species.

The highest relative abundance based on direct observation and signs of mammal presence was found on *H. malayanus* with 1.67±1.529 individuals/km in Wehea Protected Forest and 1.00±1.00 individuals/km in the natural forest area of PT. Gunung Gajah Abadi. The high relative abundance of *H. malayanus* in Wehea Protected Forest is because the area has more diverse tree species, shady tree canopy, and high density compared to the natural forest of PT. Gunung Gajah Abadi. Based on the observations, *H. malayanus* has left signs of presence in the form of scats in 4 observation lines and food in 1 observation line in Wehea Protected Forest. The locations where the signs of *H. malayanus* were found were in areas with shady trees, exposed to direct light from the sun, and close to water and food sources. The same thing was also reported by Zulkarnain (2018) in his research which states that signs of the presence of *H. malayanus* are in areas that have trees with shady crowns and are still exposed to sunlight. Furthermore, Kuswanda & Muhktar (2010) stated that *H. malayanus* is a large-sized terrestrial mammal that requires a large home range and a sustainable and undisturbed forest to support its population development.

Ecologically, the camera trap footage found by *H. malayanus* was recorded in the afternoon and evening. According to Francis (2016), *H. malayanus* species spends the day to sleep in the trees and is active at night. *H. malayanus* did a variety of diets, such as fruits, honey, termites, small mice, and birds. The results of camera trapping on *M. flavigula* were recorded from morning to evening when they were doing mobility. According to Francis (2016), *M. flavigula* performs activities during the day and spends a lot of time on land. *M. flavigula* has a varied diet including insects, eggs and nectar, frogs, birds, or squirrels. *P. hermaphroditus* were recorded in the afternoon when it was doing mobility activity in the trees. According to Francis (2016), *P. hermaphroditus* is nocturnal and often seen on the ground but feeds on trees. *P. hermaphroditus* diets on fruits, insects, small mammals, birds, lizards, nectar, and pollen from flowers on forest trees.

The results of camera trap's recordings found in the Primate, all species were recorded during the day while walking, sitting, and drinking activities. According to Francis (2016), *M. nemestrina* is a diurnal primate that performs activities during the day and the most nomadic compared to other apes. *P. pygmaeus* builds a nest consisting of broken twigs and branches that are put together and placed on a tall tree and move slowly over the ground. *P. pygmaeus* diets on young fruits and leaves. According to Cheyne, et al. (2020) *P. canicrus* is diurnal and arboreal, so it spends a lot of time in trees and sometimes these animals descend on the ground to get minerals. Cheyne, et al. (2020) stated that *P. rubicunda* is diurnal and arboreal so it spends more time in trees although they are also often on the ground.

Based on the results of the camera trap, *M. Muntjak* was recorded from morning to night when eating and moving activities. According to Francis (2016), *M. muntjak* is active during the day but sometimes they feel disturbed so they are more active at night. Furthermore, *M. muntjak* eats leaves, twigs, fruit, and fallen seeds. *R. unicolor* was recorded in the afternoon and evening during drinking activities in the sepan area. According to Francis (2016), *R. unicolor* is active at dusk and night, while resting during the day. *R. unicolor* diets on twigs, leaves, vines, buds, fallen fruit, grass, and licks saltwater in the area, especially in males who will grow new horns. In *T. kanchil* recorded in the morning when doing mobility activities. According to Timmins & Duckworth (2015) during the day, *T. kanchil* will walk in the bush on bamboo and move to higher and dry places at night. *T. kanchil* can be found in primary and secondary lowland rainforests. *T. kanchil* feeds on leaf shoots, young leaves, and fruits that fall on the forest floor.

H. brachyura was recorded in the morning while moving on the ground. According to Francis (2016) *H. brachyura* is a terrestrial mammal and dig underground holes for years. *H. brachyura* feeds on roots, tubers, bark, and fallen fruit.

From 12 species of mammals, 9 species were omnivores and 3 species were herbivores and no mammals were found to be carnivores. This grouping based on diet class shows that the balance of the ecosystem in Wehea-Kelay landscape is quite good. According to Rustam (2017), the more species in the omnivorous diet class, the more supportive it is in providing the next level of consumers with the condition that feeds are available in that habitat. So that it can form a balance of mammalian diet classes which can be used as the basis that the habitat is very suitable for mammals. Added by Solichin (1997), if a habitat has a stable community it will form a pyramid pattern based on its diet class.

In this study, observations were also made in the sepan area in Wehea Protected Forest area. The camera-trap method in the sepan area observed 5 species of mammals, such as *R. unicolor, P. pygmaeus, M. muntjak, P. canicrus*, and *P. rubicunda*. The highest number of independent photos was owned by *P. canicrus* with 6 independent photos while the lowest number of independent photos was owned by *P. pygmaeus* with 1 independent photo. For observations of mammalian activity in Sepan based on camera trap results, it has been observed that *P. pygmaeus* is only present for a moment in the Sepan area, while the other four mammals are observed to visit the Sepan area regularly and take advantage of the mineral water sources found in the Sepan area. *R.*

unicolor and *M. muntjak* visited sepan at night while *P. canicrus* and *P. rubicunda* during the day.

Matsubayashi, et al. (2006) stated that the sepan area is a place where there is water with mineral content that is important for large mammals. Sepan is also known as a place that contains high minerals. Meijaard, et al. (2006) stated that *R. unicolor* and *M. muntjak* visited a lot and took advantage of the mineral sources in sepan at night to help with digestive metabolism and neutralize leaf toxins. According to Cheyne, et al. (2020) *P. canicrus* and *P. rubicunda* are leaf-eating monkeys that depend on the sepan area to neutralize ingested leaf toxins and assist the digestive secretion process.

Based on the observation in sepan, *P. canicrus* has been observed directly and captured by camera traps. In direct observations made on January 28, 2020, 3 individuals were observed in the tree canopy. In camera traps, *P. canicrus* was observed regularly visiting sepan with 6 independent photos. On February 12, 2020, 7 individuals were observed. On February 14, 2020, 1 individual was observed. On February 16, 2020, 1 individual was observed. On February 18, 2020, 2 individuals were observed. On February 19, 2020, 2 independent photos were obtained with 8 individuals and 3 individuals each. Lhota et al. (2012) found 7 individuals of *P. canicrus* using the camera trap method in the sepan area of Wehea Protected Forest. The results of this study can be used as evidence that the environmental conditions in Sepan are stable enough to meet the needs of *P. canicrus* so that they are observed regularly visiting Sepan to consume mineral water at Sepan.

IV. CONCLUSIONS

Based on the results of the study, it can be concluded: the mammal species found in the Wehea protected forest area and the natural forest of PT. Gunung Gajah Abadi is 4 orders, 9 families and 12 species. The conservation status of 12 species of mammals found is 1 species of critical status, 2 species of appendix I, and 6 species protected by national regulations.

The highest relative abundance of mammals based on the frequency of the presence of camera traps was found in M. muntjak with a value of 5.21. The relative abundance based on direct encounter was highest in *H. malayanus* with a value of 1.67 ± 1.529 individuals/km in Wehea Protected Forest and 1.00 ± 1.00 Individuals/km in PT. Gunung Gajah Abadi.

The number of mammal species found based on direct encounters in Wehea Protected Forest was more than the natural forest of PT. Gunung Gajah Abadi.

Five mammal species were found that visited the sepan area, indicating that the area is important as a source of minerals for the life of mammal species in Wehea Protected Forest.

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