BIOGENESIS Jurnal Ilmiah Biologi

pISSN 2302-1616, eISSN 2580-2909
Vol 12, No. 1, June 2024, pp. 98-110
Available online http://journal.uin-alauddin.ac.id/index.php/biogenesis
DOI https://doi.org/10.24252/bio.v12i1.37267

Diversity of Bats (Chiroptera) in the Cimaung Cave Area, Tasikmalaya Regency

Epi Nurul Bariyah Muhtar[1], Diana Hernawati[1], Diki Muhamad Chaidir[1*]
[1]Department of Biology Education, Faculty of Education and Teacher Training, Universitas Siliwangi
Jl. Siliwangi No. 24, Tasikmalaya, West Java, Indonesia. 46115
*Email: dikimc@unsil.ac.id

ABSTRACT. Bats are the only mammals that can fly and belong to the order Chiroptera. Chiroptera consists of two suborders, namely Yangochiroptera and Yinpterochiroptera. This study aims to describe environmental factors and the diversity of bat species in the Cimaung Cave area. This research method is a quantitative descriptive research method with an exploratory approach, photo documentation, and data collection techniques using direct sweeping and a mist-net. The stations were used based on several existing zones, namely station 1 (Light Zone), station 2 (Dim Zone), and station 3 (Dark Zone). The results of research on bats found in Cimaung Cave belong to three families (Rhinolophidae, Hipposideridae, and Vespertlionidae) and four species (R. borneensis, R. affinis, H. larvatus, and M. australis). The results of the calculation of the ecological index of bats in the Cimaung cave area include the ShannonWeiner diversity index of 1.19 (moderate), the Krebs density index of 1.98 (very rare), the Simpson dominance index of 0.35 (moderate), the Krebs uniformity index of 0.86 (high) and the Magurran species richness index of 0.42 (low). Information on bat diversity in Cimaung Cave can be used as a basis for research development and utilization in the future. In addition, the presence of bat species in Cimaung Cave can also be used as a reference for education, conservation, and identification activities. As well as the utilization of the indirect economic value of bats, namely as plant pest controllers and guano providers as organic fertilizers.

Keywords: Chiroptera; Cimaung Cave; diversity of bats; ecological index; Tasikmalaya

Article History: Received 28 April 2023; Received in revised form 10 Juni 2024; Accepted 22 Juni 2024; Available online 30 June 2024.
How to Cite This Article: Muhtar ENB, Hernawati D, Chaidir DM. 2024. Diversity of bats (Chiroptera) in the Cimaung Cave Area, Tasikmalaya Regency. *Biogenesis: Jurnal Ilmiah Biologi*. vol 12(1): 98–110. doi: https://doi.org/10.24252/bio.v12i1.37267.

INTRODUCTION

Bats are animals that have a fairly high diversity in Indonesia (Rendra, 2015). Bats are small mammals that have the second largest species diversity after the order Rodentia (Baiki *et al*., 2020). Among mammals, bats have several different eating habits such as eating meat, insects, fruit, flowers, nectar, pollen and bloodsuckers (Sari *et al*., 2018). Bats belong to the order Chiroptera, which is currently classified into two sub-orders, namely Yinpterochiroptera and Yangochiroptera (Anderson & Ruxton, 2020). The diversity of bats in Indonesia reaches 230 species from all types of bats in the world (Safitri *et al*., 2020). These types include 77 species grouped into the Yangochiroptera sub-order, while 153 species are grouped into the Yinpterochiroptera sub-order (Kartono *et al*., 2017). According to (Fathoni *et al*., 2017). that it is estimated that 20% of the bats of the sub-order Yangochiroptera and more than 50% of the bats of the sub-order Yinpterochiroptera choose to roost in caves. Several bat families found in Indonesia, including the families Pteropodidae, Rhinolophidae, Hipposideridae and Rhinopomatidae which are included in the Sub-order Yinpterochiroptera and families such as Vespertilionidae, Emballonuridae, Miniopteridae, Molossidae, Megadermatidae, Nycteridae and Palaeochiropterygidae which are included in the Sub-order Yangochiroptera (GBIF.org, 2024).

Bats play an important role in ecosystem sustainability and maintain the stability of tropical rainforests (Mustari *et al*., 2021; Saiful *et al*., 2021). Some of the important roles of bats in ecosystem services dan indirectly beneficial to humans are to help disperse seeds and pollinate flowers, nutrient cycling, as well as control insect populations, such as controlling plant pests (Kartono *et al*., 2017; Castillo-Figueroa, 2020; Safitri *et al*., 2020; Brasileiro *et al*., 2022;). Bats that help in the pollination process also have a positive impact on the local economy and its own cultural value for the local community (Sheherazade *et al*., 2019). The guano of this bat in addition to having benefits as a source of energy and nutrients from cavernicolous organisms, if it has economic value becomes a fertilizer that can be sold (Sakoui *et al*., 2020; Akmali *et al*., 2022). Even though bats have an important role for human life, it turns out that many have ruled out the role of bats in life.

There are things that cause bats to be ruled out, one of which is due to the lack of public knowledge about the importance of bats in the ecological chain (Kartono *et al*., 2017). Another cause of the threat of bat populations is overhunting for human consumption dan certain medications which is even an direct economic value sold in the market (Nangoy *et al*., 2021; Ransaleleh *et al*., 2020). In fact, so far there has been a decline in bat populations around the world, in fact several types of bats have been declared extinct and other species are reported to be in the process of going extinct (Falcao *et al*., 2003) in (Safitri *et al*., 2020)). Based on data from IUCN (International Union for Conservation of Nature), of the 1150 bat species recorded, 15% of them are threatened with extinction (Welch & Beaulieu, 2018). Some of the main causes of the decline in bat populations are habitat degradation, caused by logging, land conversion, and forest fires which are also caused by human activities and natural phenomena (Safitri *et al*., 2020). Based on this, it is important to also protect bat habitats that are generally found in forests and caves. Bats live in various types of habitats such as caves, natural forests and plantations. In general, the habitat of bats is in closed and moist areas. Bats that live in caves are usually 20% fruit-eating bats and 50% insect-eating bats (Sumarni & Fathurrachman, 2019).

Bats have their own character to be able to live in a cave habitat (Piter *et al*., 2015). During the day, bats are mostly found in caves, while during the night, they disperse (Medellin *et al*., 2017). Several types of bats choose caves as nesting sites because the cave conditions are humid, absence of natural light,the temperature is stable, far from noise and protection against predators (De Oliveira *et al*., 2018; Kurniawan *et al*., 2018; Sella *et al*., 2019). A cave is a natural formation in the form of a karst chamber formed on a limestone or limestone terrain under the ground, either standing alone or the relationship between one space and another caused by the process of dissolving either by water or geological activity (Uca & Angrian, 2018). In Indonesia, especially the island of Java, the potential number of caves can reach hundreds scattered along the island (Sahrina *et al*., 2022). One of the areas on the island of Java that has many caves is Tasikmalaya, West Java.

Based on data from the Tasik Caving Community (TCC), there are ±500 caves, and ±350 of them have been mapped and scattered of various areas in Tasikmalaya (Hidayaturrohmah *et al*., 2021). Cimaung Cave is a cave located in Linggaraja Village, Sukaraja District, Tasikmalaya Regency. The type of Cimaung Cave is a karst (limestone) cave that can become a clean water aquifer. There is an important function for living things considering the physical properties of limestone, which makes the cave able to capture and store water for the living things in the cave. In addition, based on public information, in 2015, the community still used the cave only to take the guano, although since 2019, this has not been done. Based on the level of light intensity, Cimaung Cave has 3 different zones, namely the light zone, the dim zone, and the dark zone. In that zone, there are bats that often pass by and also hang on the cave walls. Therefore, Cimaung Cave has the potential to be a place for research on the diversity of bats. It is important to conduct research in Cimaung Cave, because its existence is eroded by plantation areas, and many landslides enter the cave. This will be a threat to the existence of bats in the Ciamung Cave. By knowing the various types of bats in Cimaung Cave, it is hoped that the surrounding community will be more aware of the role of bats as pest collectors and reuse guano as a fertilizer that has economic value as well (Culver & Pipan, 2019). In addition, information about these species can also contribute to the distribution of discovered species and other research, for example in the field of molecular biology.

The closest research on bats that has been done around Tasikmalaya is in other cave locations, where several species were found such as in Liang Boeh cave there is a species of *Hipposideros* sp., Liang Sengit there is a species of *Miniopterus* sp., and Sarongge Cave there is a species of *Rhinolophus* sp. (Kurniawan *et al*., 2020). Based on the initial survey conducted by conducting discussions with the local community, no data has been documented regarding the various species and diversity of bats in Cimaung Cave. So that its existence is unknown, limited information regarding the existence of bat diversity and seeing the important role of bats in the ecosystem, it is necessary to conduct research on the study of bat diversity in Cimaung Cave This study aims to describe the diversity of bats (Chiroptera) found in the Cimaung Cave area, Tasikmalay Regency. Information on the diversity of bats in Cimaung Cave can be used as a basis for research development and future utilization. In addition, the presence of bat species in the Cimaung Cave can also be used as a reference for conservation and identification activities.

MATERIALS AND METHODS

Study area. This research was conducted in the Cimaung Cave Area which is administratively located in Linggaraja Village, Sukaraja District, Tasikmalaya Regency (Latitude -7.4286151556, Longtitude 108.136937432).

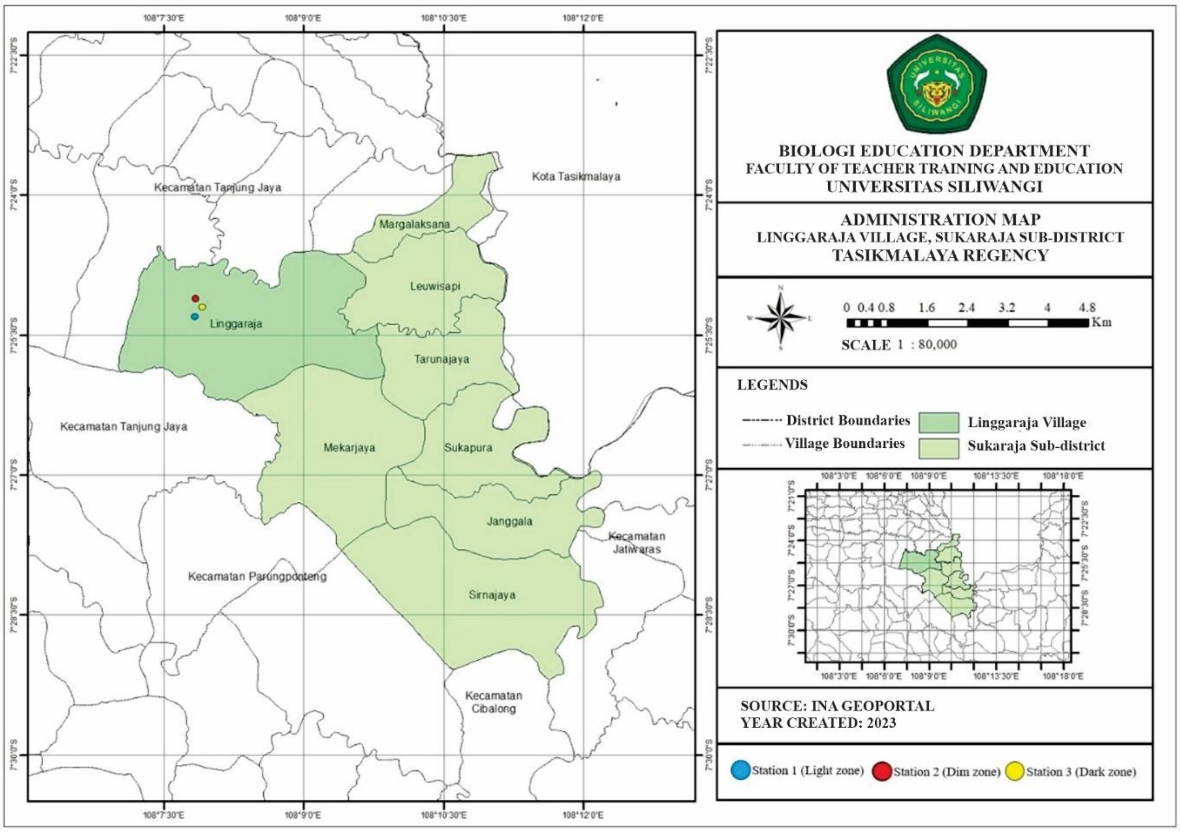


Fig. 1. Research locations in Cimaung Cave area

The observation stations in this study were located in the Cimaung Cave area, namely station 1 (light zone), station 2 (dim zone) and station 3 (dark zone). The division of the cave zone as a research station can be seen in Figure 2. In figure 2, it looks bright because it uses an external flash of a digital camera when documenting, but in this picture, it also aims to show information about bat colonies in each cave zone.

Fig. 2. Research station: a. Station 1 (light zone); b. Station 2 (dim zone); c. Station 3 (dark zone).

Procedures. This research uses a quantitative descriptive research method with an exploratory approach and uses a camera to see directly. Research samples were taken in Cimaung Cave on 11, 14 and 16 February 2023 during the day at 09.00 AM to 03.00 PM. Bats were caught only 10 individuals for sampling, documentation and further identification needs in the laboratory. Sampling is carried out using direct sweeping and using a mistnet then anesthesia by placing the bats in a jar containing 5% chloroform and preserved by wet preservation. To make the wet preservation, we put the dead bat into a bottle containing a 70% alcohol solution and store it for further identification. Then the samples were identified using the book Bats: An Illustrated Guide to All Species (Taylor, 2017) and the book Bats Indonesia (Suyanto, 2001),. Environmental parameters were also calculated, including: temperature, light intensity, wind speed, air humidity and soil pH. As for some of the equipment used when collecting data for measuring environmental parameters, namely hygrometer to calculate temperature and humidity, lux meter to calculate sunlight intensity, anemometer to calculate wind speed, and soil pH to calculate soil pH. This measurement was repeated 5 times in each zone and then the average value was taken.

Data analysis. The ecological index calculations performed included the ShannonWiener diversity index (H'), Krebs density index (D), Simpson dominance index (C), Eveness uniformity index (E) and Magurran species richness index (R).

Shannon Wiener Diversity Index (H'). According to (Odum & Srigandono, 1993), the Shannon-Wiener diversity index is as follows:

$$\mathbf{H'} = -\sum_{i=1}^{s}\left(\frac{ni}{N}\right)\ln\left(\frac{ni}{N}\right)$$

Information:
H' = Shannon-Wiener Diversity Index
ni = Number of individual species
N = Number of species
S = Total number of individuals of all species

Odum & Srigandono (1993), states the following conditions:

H' < 1 = Low (unstable)
1 < H' ≤ 2 = Moderate
H' > 2 = High (stable)

Density index (D). The density index is calculated based on (Krebs, 1978) is as follows:

$$\mathbf{D} = \frac{Ni}{A}$$

Information:
D = Individual density
Ni = Number of individuals it-i
A = Total area of collection of species (m^2)

Rank of Square Density (Djamali & Darsono, 2005)

1-5 = Very Rare
5-10 = Rare
10-20 = Enough
20-50 = Abundant
>50 = Very abundant

Dominance index (C). The dominance index according to Simpson (Odum & Srigandono, 1993)) is as follows:

$$\mathbf{C} = \left(\frac{ni}{N}\right)^2$$

Information:
C = dominance index
ni = total number of individuals of type i
N = Number of all individuals in total n

Odum & Srigandono (1993) states the following conditions:
0.01 < C < 0.30 = Low dominance
0.31 < C ≤ 0.60 = Moderate dominance
0.61 < C ≤ 1.00 = High dominance

Uniformity index (E). According to (Odum & Srigandono, 1993) the uniformity index uses the following equation:

$$\mathbf{E} = \frac{\boldsymbol{H}}{\boldsymbol{In\,S}}$$

Information:
E = Uniformity index
H' = Shannon-Weiner diversity index
S = Number of species

The range of uniformity index according to (Odum & Srigandono, 1993) as follows:
E < 0.3 = Small population uniformity
0.3 < E ≤ 0.6 = Moderate population uniformity
E > 0.6 = High population uniformity

Species richness index (R). According to (Magurran, 1988) the species richness index uses the following equation:

$$\mathbf{R} = \frac{(\boldsymbol{S}-\mathbf{1})}{\ln \boldsymbol{N}}$$

Information:
D_{mg} = Margalef species richness index
S = Number of families
N = Total individuals in the sample

Criteria for Richness Index values
R < 2,5 = Low species richness
2,5 > R < 4 = Moderate species richness
R > 4 = High species richness

RESULTS AND DISCUSSION

The results of research in the Cimaung Cave area obtained 4 types of bats from 613,11 m^2 observation area. The species found were *Rhinolophus borneensis*, *Rhinolophus affinis*, *Hipposideros larvatus* and *Miniopterus australis*. The classification of bats in Cimaung Cave can be seen in Table 1.

Table 1. Types of bats (Chiroptera) in the Cimaung Cave Area

Sub Order	family	Species	Station			∑
			1	2	3	
Yinpterochiroptera	Rhinolophidae	*R. borneensis*	14	97	243	354
	Hipposididae	*R. affinis*	-	84	107	191
	Hipposididae	*H. larvatus*	-	-	582	582
Yangochiroptera	Vespertilionidae	*M. australis*	22	63	-	85
	Sum		36	244	932	1.212

Notes: Station 1 (Light Zone); Station 2 (Dim Zone); Station 3 (Dark Zone)

The following results of morphometric measurements for each bat species that have been found in the Cimaung Cave Area are described in Table 2.

Table 2. Results of morphometric measurements of each bat species in the Cimaung Cave area

Species	Gender	KT (mm)	BS (mm)	LB (mm)	Q (mm)	E (mm)	KB (mm)
R. borneensis	♂	37	198	39	10	11	6
	♀	60	133	52	15	9	8
R. affinis	♂	51	120	55	12	9	3
	♀	54	127	53	14	8	7
H. larvatus	♂	52	141	54	11	25,3	7
M. australis	♂	44	139	42	14	41	5
	♀	54	142	49	5	42	6

Notes: Head and Body Length (KT); Wingspan Length (BS); Forearm Length (LB); Ear Length(T); Tail Length (E) and Hind Leg Length (KB)

The following is an explanation of the Bat (Chiroptera) which was found in the Cimaung Cave Area, Tasikmalaya Regency.

1. *Rhinolophus borneensis* (Peters, 1861)

R. borneensis has the characteristics of small eyes, nostrils that do not cover the mouth, no lapets, slightly convex sella, triangular connecting taju and black wings. The hair color on the upper and lower body is black mixed with gray (Prasetyo *et al*., 2011). According to (Suyanto, 2001) *R. borneensis* has a distribution area starting from Kalimantan, Sumatra, Java, Nusa Tenggara, and Continental Asia (India to the east to South China). On the IUCN, *R. borneensis* is listed as *Least Concern* (LC) status or low risk (Jayaraj, 2020a). The documentation of based on findings in the Cimuang Cave area can be seen in Figure 3, based on the observation results of this species in its natural habitat it is found with a number of individuals up to hundreds and uses its perch to feed (Jayaraj, 2020b).

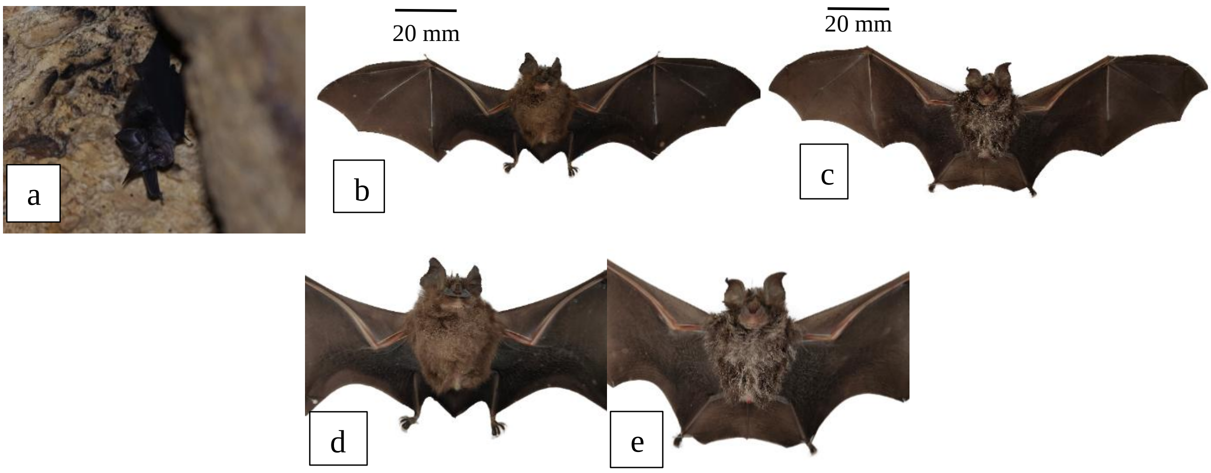


Fig. 3. a. *R. borneensis* found in the Cimaung Cave area (natural photo); b. *R. borneensis* male (Studio photo); c. *R. borneensis* female (Studio photo); d. *R. borneensis* male (Studio photo at 2.5 times magnification); e. *R. borneensis* female (Studio photo at 2.5 times magnification). (All photos are documented by the author)

2. *Rhinolophus affinis* (Horsfields, 1823)

R. affinis has the following characteristics the upper body is dark brown while the lower body is lighter brown and blackish on the groin, has small eyes, the tail sinks completely into the skin between the thighs, the ears have a round antitragus and has a tragus (Baiki *et al*., 2020). *R. affinis* does not have a second toe claws, has a complex nostrils. The parts of the *R. bat's nose* are the lancet, hind nostrils, connecting taju, sella, lapet and front nostrils. Bat noses are often known as horseshoes because of the lancets and leaves of the back nose like horseshoes (Sari, 2016). *R. affinis* memiliki 9 subspesies berdasarkan distribusinya, untuk wilayah Indonesia yaitu pada pulau jawa yaitu *R. affinis affinis* horsefield, *R. a. nesite* Andersen (type locality Bunguran Island, North Natunas, Indonesia), *R. a. princeps* Andersen (type locality Lombok, Lesser Sunda Island), serta wilayah asia lainnya antara lain *R. a. andamanensis* Dobson (type locality South Andaman Island), *R. a. himalayanus*

Andersen (type locality Mussoorie, Kumaon Division, northern India), *R. a. tener* Andersen (type locality Pegu Division, recently known as Bago, Myanmar), *R. a. macrurus* Andersen (type locality Taho, Karennee, Kyah State, Myanmar), *R. a. superans* Andersen (Pahang, peninsular Malaysia), and *R. a. hainanus* Allen (type locality Pouten, Hainan Island). (Ith *et al*., 2015).

According to (Suyanto, 2001) *R. affinis* has a distribution area starting from Sumatra, Kalimantan, Java, Nusa Tenggara, Malaysia and Continental Asia (India to the east to South China). On the IUCN, *R. affinis* is listed as *Least Concern* (LC) status or low risk (Furey *et al*., 2020). The documentation of *R. affinis* based on findings in the Cimuang Cave area can be seen in Figure 4. Throughout the observation inside the cave, this type is quite sensitive to light, when turning on the headlamp, all immediately fly and dodge.

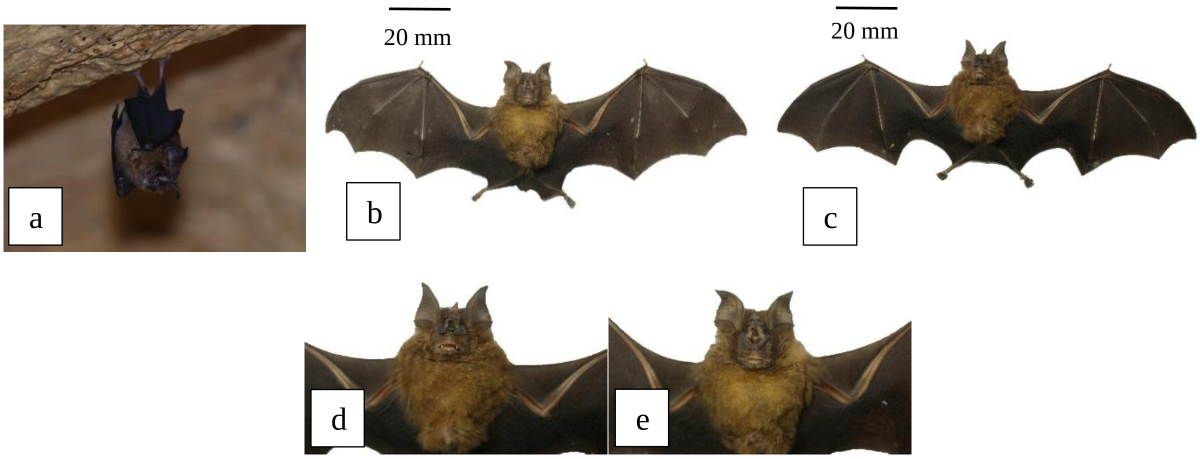


Fig. 4. a. *R. affinis* found in the Cimaung Cave area (natural photo); b. *R. affinis* male (Studio photo); c. *R. affinis* female (Studio photo); d. *R. affinis* male (Studio photo at 2.5 times magnification); e. *R. affinis* female (Studio photo at 2.5x magnification). (All photos are documented by the author)

3. *Hipposideros larvatus* (Horsfield, 1823)

H. larvatus is one of the bats known as the medium barong. Characteristics of *H. larvatus* it is upper body dark gray brown, has tail completely immersed in interdental sheath, ears have short antitragus, no claws on second toe, ears are unconnected on top of head and nose and face have leaflike structures which shaped like horseshoes (Nurfitrianto *et al*., 2013). According to (Suyanto, 2001) *H. larvatus* has a distribution area ranging from Sumatra, Kalimantan, Java, Nusa Tenggara, Malaysia, Singapore, Thailand, Vietnam, China Myanmar and India. On the IUCN, *H. larvatus* s listed as *Least Concern* (LC) status or low risk (Srinivasulu & Srinivasulu, 2020). The documentation *of H. larvatus* based on findings in the Cimuang Cave area can be seen in Figure 5. *H. larvatus* at the time of observation in the Ciamung Cave, tends to occupy the darkest location and is sensitive to the light used at the time of observation. In addition, this type is also very sensitive to sound, therefore it is found in the observation location furthest from the mouth of the cave (dark zone). This type is also found in colonies that live together and usually have behavior that mimics echolocation to each other when they live in pairs (Chen *et al*., 2016).

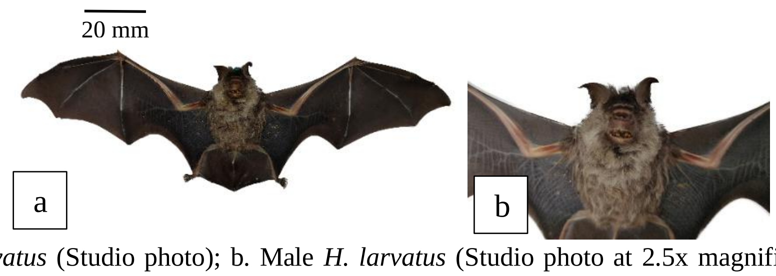


Fig. 5. a. Male *H. larvatus* (Studio photo); b. Male *H. larvatus* (Studio photo at 2.5x magnification). (All photos are documented by the author)

4. *Miniopterus australis* (Tomes, 1858)

M. australis has the following characteristics, namely the size of the last phalanx on wing number three, its length is more than three times the length of the first phalanx, short rounded ears with two folds at the back with a blunt short tragus curved slightly forward, has a tail where the entire tail is immersed in membrane between the thighs (Tamasuki *et al*., 2008). *M. australis* is spread in Kalimantan, Sumatra, Java, Nusa Tenggara, and Continental Asia (India to the east to South China). On the IUCN, *M. australis* is listed as *Least Concern* (LC) status or low risk (Armstrong *et al*., 2021). The documentation of *M. australis* based on findings in the Cimuang Cave area can be seen in Figure 6. *M. australis* was found in a location near the mouth of the cave where there is still light intensity.

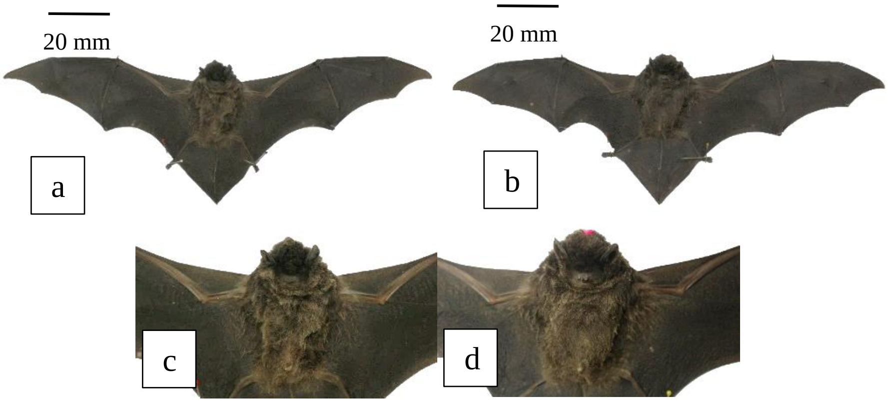


Fig. 6. a. *M. australis* male (Studio photo); b. *M. australis* female (Studio photo); c. *M. australis* male (Studio photo at 2.5 times magnification); d. *M. australis* female (Studio photo at 2.5 times magnification). (All photos are documented by the author)

According to (Piter *et al*., 2015) bats have their own characteristics to be able to live in cave habitats. Air temperature, air humidity, light intensity and wind speed are important factors for the survival of the bat population in the cave. The results regarding the measurement of environmental parameters in the Cimaung Cave area can be seen in Table 3.

Table 3. Results of environment measurements of each station in the Cimaung Cave area

No	Parameter	Station 1 (Light Zone)	Station 2 (Dim Zone)	Station 3 (Dark Zone)	Average
1	Temperature	28,80 °C	28,31 °C	27,33 °C	28,15 °C
2	Light intensity	0,25 lux	0,18 lux	0 lux	0,14 lux
3	Wind velocity	0,30m/s	0,02m /s	0 m/s	0,11 m/s
4	Humidity	77,67 %	86,67 %	87,53 %	83,96 %
5	Soil pH	6,77	7	7	6,92

After measuring enviroment factors in the cave for each station, then analysis was carried out using Canonical Correspondence Analysis (CCA) to see the relationship between climatic data and the number of individuals of each bat species found in the cave. The analysis was carried out using the Past 4 software and then obtained the following graph results. Based on Figure 7, it can be seen that *M. australis* is a species that is more commonly found in the bright zone that has the highest light intensity, the zone is also a zone close to the mouth of the cave and has a higher temperature. While the *H. larvatus* species is a species that prefers high humidity levels and light intensity, that does not exist at all. *R. affinis* is found in the dim zone and dark zone, but tends not to correlate with the observed environmental factors. *R. borneosis* is a species that has a higher tolerance to observed environmental factors compared to other species, because it is found in all zones and is close to the various environmental factors observed.

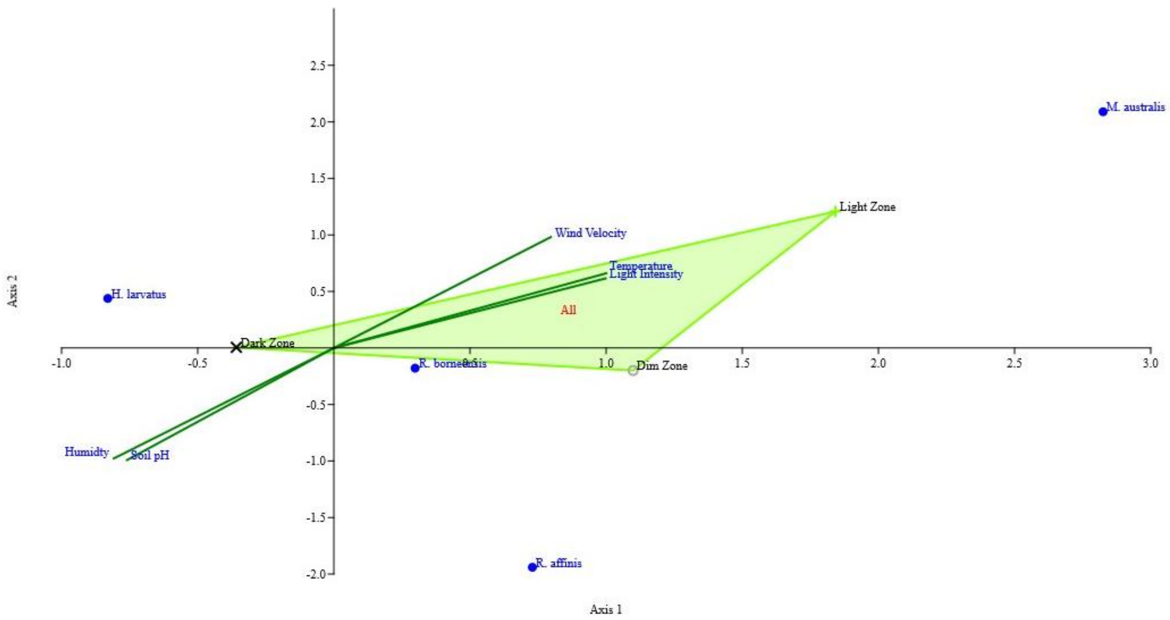


Fig. 7. Canonical Correspondence Analysis (CCA) diagram showing the ordination of bats species in Cimaung Caves along the first two axes and their correlation with environmental variables

One of the factors that influences bat habitat is temperature. Temperature is an important factor for the life of bats. Several types of bats choose caves as nesting places because of the stable temperature conditions. The appropriate temperature for bats' living environment ranges from 25°C to 30°C (Piter *et al*., 2015). The temperature in Cimaung Cave ranges from 27.33°C to 28.80°C. Apart from temperature, bats usually live in low light intensity (dark). For bats, dark places provide protection from predators. The light intensity in the Cimaung cave ranges from 0 lux to 0.25 lux. Apart from the dark conditions, Cimaung Cave has low wind speeds. The wind speed inside Cimaung Cave is relatively low, namely 0 m/s to 0.25 m/s. The low wind speed in Cimaung Cave is influenced by the shady tree cover in front of the cave mouth and is blocked by the cave walls so that it cannot enter the cave. Several types of bats choose caves as nesting places because of the damp conditions in the caves. High humidity conditions will be preferred by bats. High humidity is caused by the cave walls being formed by rocks, and there is water seepage coming out of the cave walls and cave roof (Piter *et al*., 2015). The limitations in this study are other factors that are important but not measured as other environmental indicators, namely oxygen levels, carbon dioxide levels, and noise levels in the cave, which also affect the presence of bats in the cave (Wijayanti & Maryanto, 2017; Culver & Pipan, 2019). After knowing how environmental conditions are related, the next is an analysis of the ecological index.

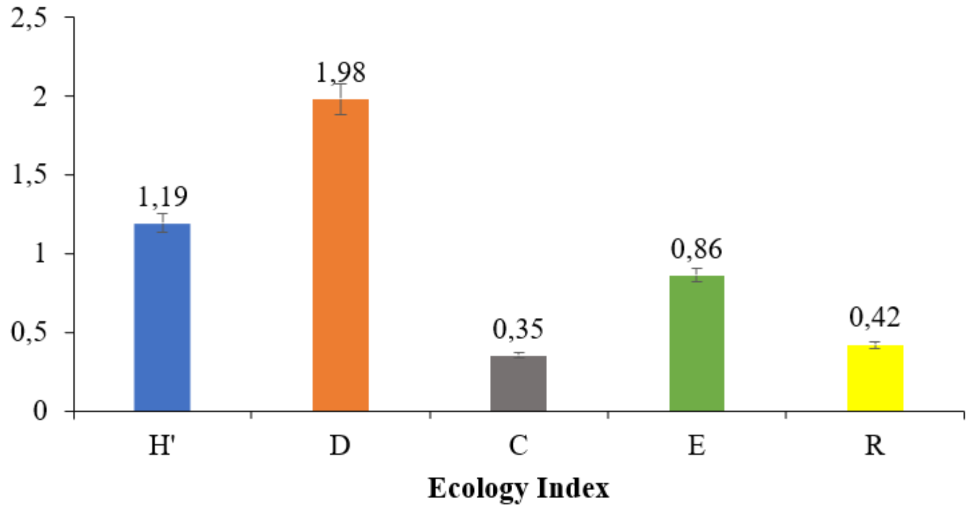
The results of the calculation of the ecological index values which include the stretch index, density index, dominance index, uniformity index and species richness index as a whole in the Cimaung Cave area can be seen in Table 4.

Table 4 . Results of ecological index of bats in the Cimaung Cave area

Ecologi index	Value	Category
Shannon-Weiner Diversity index (H')	1,19	Moderate
Krebs Density index (D)	1,98	Very Rare
Simpson Dominance index (C)	0,35	Moderate
Krebs Uniformity index (E)	0,86	High
Magurran Species richness index (R)	0,42	Low

Note: (-) = There is no category for the density index (D)

Based on Table 4, a comparison chart is made for each ecological index in the diagram in Figure 8 as follows:



Notes : H' = diversity index, D = density index, C = dominance index, E = Uniformity index, R = species richness indez

Fig. 8. Diagram of bats ecological indeks values in the Cimaung Cave Area

Based on Table 4 and Figure 7 it can be seen that the Shannon-Wiener index value of bat diversity in the Cimaung Cave area of 1.19 (moderate) category, which indicates sufficient productivity, fairly balanced ecosystem conditions for bats, moderate ecological pressure. Shannon-Wiener Density index of 1.98 (very rare) which indicates that the condition of the cave is still large enough to be occupied by bats, although the number is quite abundant, but the area of the cave can still accommodate as a habitat for bats, dominance index of 0.35 (moderate) which indicates the absence of dominating species in the cave, because the number of individuals in some species is quite large, uniformity index of 0.86 (high) This indicates that the species found in Cimaung Cave are very uniform and species richness index of 0.42 (low) This indicates the number of individuals found but only four species exist, thus indicating a low species richness.

The bats species found in this study, some of which were also found in the research conducted by (Nurfitrianto *et al*., 2013) and (Tamasuki *et al*., 2015). The discovery of the same bats species as other studies could be caused by the stable conditions of the cave, the available bat food sources, the absence of predators so that there are still many bat species living in caves. The existence of bat species that were not found in this study with other studies could be caused by several factors, the main factor being that this study only concentrated on bats that inhabit caves, therefore researchers only made an inventory of bat species that were in caves. In addition, there is still a chamber in the cave that is difficult for humans to reach that does not allow entering the chamber to see the types of bats that exist. Certain seasons will also affect the population dynamics of the bats in the cave (Jung & Threlfall, 2016)

This study indicate that there are four types of bats species in Cimaung Cave, namely *R. borneensis*, *R. affinis*, *H. larvatus*, and *M. australis.* This developed from previous research on bats in several caves in Tasikmalaya where several species of *Hipposideros* sp, *Miniopterus* sp, and *Rhinolophus* sp. (Kurniawan et al., 2020). There are types of bats that can be observed from the images presented and also data regarding the environmental parameters of the Cimaung Cave can be an insight into the diversity of bats.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the bats found in Cimaung Cave are *R. borneensis*, *R. affinis*, *H. larvatus*, and *M. australis* with an observation area of 613.11 m² at three different stations, namely Station 1 (Light Zone), Station 2 (Dim Zone) and Station 3 (Dark Zone). The results of the calculation of the ecological index of bats in the Cimaung Cave area include the Shannon-Wiener diversity index of 1.19 (moderate), the krebs density index of 1.98 (very rare), the Simpson dominance index of 0.35 (moderate), the Krebs uniformity index of 0.86 (high), and the Magguran species richness index of 0.42 (low). Information on bat diversity in Cimaung Cave can be used as a basis for research development and utilization in the future. In addition, the presence of bat species in Cimaung Cave can also be used as a reference for education, conservation and identification activities. As well as the utilization of the indirect economic value of bats, namely as plant pest controllers and guano providers as organic fertilizers.

ACKNOWLEDGEMENTS

We thank Mr. Endis Nasihin and residents of Linggaraja village who have given research permission and motivation, Helmalia Aldona, Sandi and Ferry who have helped a lot in collecting data in the field, Silvia and Fahmi Muhamad Fauzi who always provide information about analyzing the data. The author also expressed his gratitude to Tasikmalaya Caving Community for providing a lot of advice and assistance with research activities.

REFERENCES

Akmali V, Abedini S, Malekpour FZ. 2022. Bat fauna and conservation assessment of Kurdistan Caves, Iran. *Subterranean Biology*, vol 42: 79–95. doi: https://doi.org/10.3897/subtbiol.42.73282.

Anderson SC, Ruxton GD. 2020. The evolution of flight in bats: a novel hypothesis. *Mammal Review*, vol 50(4): 426–439. doi: https://doi.org/10.1111/mam.12211.

Armstrong KN, Wiantoro S, Aplin K. 2021. *Miniopterus australis*. The IUCN Red List of Threatened Species 2021: E.T13562A209528942.

Baiki KA, Efrialda PP, Winarno AS. 2020. Keanekaragaman jenis kelelawar di Gua Grudo, Kawasan Karst Gunung Sewu, Gunungkidul, Yogyakarta.

Brasileiro LAM, Machado RB, Aguiar LMS. 2022. Ecosystems services provided by bats are at risk in Brazil. *Frontiers in Ecology and Evolution*, vol 10: 1-15. doi: https://doi.org/10.3389/fevo.2022.852177.

Castillo-Figueroa D. (2020). Why bats matters: a critical assessment of bat-mediated ecological processes in the Neotropics. *European Journal of Ecology*, vol 6(1): 77–101. doi: https://doi.org/10.17161/eurojecol.v6i1.13824.

Chen Y, Liu Q, Su Q, Sun Y, Peng X, He X, Zhang L. 2016. 'Compromise' in echolocation calls between different colonies of the intermediate leaf-nosed bat (*Hipposideros larvatus*). *PLOS ONE*, vol 11(3), 1-10. doi: https://doi.org/10.1371/journal.pone.0151382.

Culver D, Pipan T. 2019. *The Biology of Caves and Other Subterranean Habitats*. Oxford: Oxford University Press. doi: https://doi.org/10.1093/oso/9780198820765.001.0001.

De Oliveira HFM, Oprea M, Dias RI. 2018. Distributional patterns and ecological determinants of bat occurrence inside caves: A broad scale meta-analysis. *Diversity*, vol 10(3): 1-14. doi: https://doi.org/10.3390/d10030049.

Djamali A, Darsono P. 2005. *Petunjuk Teknis Lapangan untuk Penelitian Ikan Karang di Ekosistem Terumbu Karang*. Jakarta: Pusat Dokumentasi dan Informasi Ilmiah-LIPI.

Furey N, Walston J, Kingston T, Hutson AM. 2020. *Rhinolophus affinis*. The IUCN Red List of Theretened Species: E.T19522A21982358.

GBIF.org. 2024. *GBIF Occurance*. doi: https://doi.org/https://doi.org/10.15468/dl.vwszd4.

Hidayaturrohmah N, Hernawati D, Chaidir, DM. 2021. Keanekaragaman Arthropoda berdasarkan 3 zona pencahayaan di Gua Sarongge Tasikmalaya. *Biotik: Jurnal Ilmiah Biologi Teknologi dan Kependidikan*, vol 8(2): 245-258. doi: https://doi.org/10.22373/biotik.v8i2.7778.

Ith S, Bumrungsri S, Furey NM, Bates PJ, Wonglapsuwan M, Khan FAA, Thong VD, Soisook P, Satasook C, Thomas NM. 2015. Taxonomic implications of geographical variation in *Rhinolophus affinis* (Chiroptera: Rhinolophidae) in mainland Southeast Asia. *Zoological Studies*, vol 54(31): 1-29. doi: https://doi.org/10.1186/s40555-015-0109-8.

Jayaraj VK. 2020a. *Rhinolophus borneensis*. The IUCN Red List of Threatened Species 2020: E.T19527A21982599.

Jayaraj VK. 2020b. *Rhinolophus borneensis*, Bornean Horseshoe Bat. The IUCN Red List of Threatened Species.

Jung K, Threlfall CG. 2016. Urbanisation and its effects on bats—A global meta-analysis. In *Bats in the Anthropocene: Conservation of Bats in a Changing World*. New York: Springer International Publishing. doi: https://doi.org/10.1007/978-3-319-25220-9_2.

Kartono AP, Prayogi KD, Maryanto I. 2017. Keanekaragaman jenis kelelawar di Hutan Pendidikan Gunung Walat Sukabumi Jawa Barat. *Zoo Indonesia*, vol 26(1), 33–43.

Kurniawan ID, Rahmadi C, Caraka RE, Rahman IA, Kinasih I, Toharudin T, Chen RC, Lee Y. 2020. Correspondence between bats population and terrestrial cave-dwelling arthropods community in Tasikmalaya karst area. *Commun. Math. Biol. Neurosci.*, vol 2020: 1-21. doi: https://doi.org/10.28919/cmbn/4830.

Kurniawan ID, Soesilohadi RCH, Rahmadi C, Caraka RE, Pardamean B. 2018. The difference on Arthropod communities' structure within show caves and wild caves in Gunungsewu Karst area, Indonesia. *Ecol Environ Conserv*, vol 24(1): 81–90.

Magurran AE. 1988. *Ecological Diversity and Its Measurement*. Netherlands: Springer Netherlands. doi: https://doi.org/10.1007/978-94-015-7358-0.

Medellin RA, Wiederholt R, Lopez-Hoffman L. 2017. Conservation relevance of bat caves for biodiversity and ecosystem services. *Biological Conservation*, vol 211, 45–50. doi: https://doi.org/10.1016/j.biocon.2017.01.012.

Mustari A, Putri A, Masyud B. 2021. *Panduan Lapang Kelelawar Hutan Batang Toru, Sumatera Utara (Field guide of bats of Batang Toru Forest, North Sumatra)*. Bogor: IPB Press.

Nangoy M, Ransaleleh T, Lengkong H, Koneri R, Latinne A, Kyes RC. 2021. Diversity of fruit bats (Pteropodidae) and their ectoparasites in Batuputih Nature Tourism Park, Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, vol 22(6): 3075-3082. doi: https://doi.org/10.13057/biodiv/d220609.

Nurfitrianto H, Budijastuti W, Faizah U. 2013. Kekayaan Jenis Kelelawar (Chiroptera) di Kawasan Gua Lawa Karst Dander Kabupaten Bojonegoro. *LenteraBio*, vol 2(2): 143–148.

Odum EP, Srigandono B. 1993. *Dasar-dasar Ekologi* (1st ed.). Yogyakarta: Gadjah Mada University Press.

Piter F, Setyawati TR, Lovadi I. 2015. Karakteristik populasi dan habitat kelelawar *Hipposideros cervinus* (Sub ordo Microchiroptera) di Gua Bratus Kecamatan Air Besar Kabupaten Landak. *Jurnal Probiont*, vol 4(1), 77–83. doi: https://doi.org/10.26418/protobiont.v4i1.9477.

Prasetyo PN, Noerfahmy S, Tata, HL. 2011. *Jenis-Jenis Kelelawar Khas Agroforest Sumatera Jenis-Jenis Kelelawar Khas Agroforest Sumatera*. Bogor: World Agroforestry Centre (ICRAF) Southeast Asia.

Ransaleleh T, Nangoy M, Wahyuni I, Lomboan A, Koneri R, Saputro S, Pamungkas J, Latinne A. 2020. Identification of bats on traditional market in dumoga district, North Sulawesi. *IOP Conference Series: Earth and Environmental Science*, 473(1): 1-7. doi: https://doi.org/10.1088/1755-1315/473/1/012067.

Rendra IDF. 2015. Keanekaragaman kelelawar ciampea. *Prosiding Seminar Nasional Pendidikan Biologi dan Biolog*: 97-106.

Safitri Z, Prayogo H, Erianto. 2020. Keanekaragaman jenis kelelawar (Chiroptera) di Kawasan Universitas Tanjungpura Kota Pontianak. *Jurnal Hutan Lestari*, vol 8(2): 429–440. doi: https://doi.org/10.26418/JHL.V8I2.40922.

Sahrina A, Fadlan MS, Withuda FA, Labib MA, Fitriani D, Ma'asika NM. 2022. Elaborative analysis of caves as specified tourism destination in Malang Regency-Indonesia. *GeoJournal of Tourism and Geosites*, vol 41(2): 368–375. doi: https://doi.org/10.30892/gtg.41205-839.

Saiful M, Febrina HS, Fauzan M, Maisa DRV, Maolani A, Suryanda A, Dewahrani YR. 2021. Studi literatur perbandingan keanekaragaman kelelawar di Pulau Kalimantan dan Jawa. *BIO-EDU: Jurnal Pendidikan Biologi*, vol 6(3): 185–197. doi: https://doi.org/10.32938/jbe.v6i3.1338.

Sakoui S, Derdak R, Addoum B, Serrano-Delgado A, Soukri A, El Khalfi B. 2020. The life hidden inside caves: ecological and economic importance of bat Guano. *International Journal of Ecology*, vol 2020: 1–7. doi: https://doi.org/10.1155/2020/9872532

Sari DN. 2016. Studi komparasi struktur anatomik noseleaf kelelawar *Rhinolophus affinis* dan *Hipposideros ater*. *Jurnal Biologi*, vol 5(6): 38–49.

Sari MDP, Jusmaldi, Sudiastuti. 2018. Karakteristik morfologis dan histologis saluran pencernaan kelelawar pemakan buah (*Cynopterus brachyotis*). *Jurnal Sains dan Pendidikan Biologi*, vol 2: 14–24.

Sella S, Prayogo H, Erianto E. 2019. Keanekaragaman jenis kelelawar (Chiroptera) di Kebun Raya Sambas Kabupaten Sambas Kalimantan Barat. *Jurnal Hutan Lestari*, vol 7(4): 1653–1659. doi: https://doi.org/10.26418/jhl.v7i4.38247.

Sheherazade, Ober HK, Tsang SM. 2019. Contributions of bats to the local economy through durian pollination in Sulawesi, Indonesia. *Biotropica*, vol 51(6): 913–922. doi: https://doi.org/10.1111/btp.12712.

Srinivasulu C, Srinivasulu A. 2020. *Hipposideros larvatus*. The IUCN Red List of Threatened Species 2020: E.T85646564A22091287.

Sumarni S, Fathurrachman S. 2019. Studi jenis kelelawar (Chiroptera) di Gua Kelelawar pada kawasan Bukit Beluan Kecamatan Hulu Gurung Kabupaten Kapuas Hulu. *Piper*, vol 15(29): 178-194. doi: https://doi.org/10.51826/piper.v15i29.342.

Suyanto A. 2001. *Kelelawar di Indonesia*. Bogor: Puslitbang Biologi - LIPI.

Tamasuki K, Wijayanti F, Fitriana N. 2008. Komunitas kelelawar (Ordo CHiroptera) di beberapa Gua Karst Gunung Kendeng Kabupaten Pati Jawa tengah. *Al-Kauniyah Jurnal Biologi*, vol 8(2): 88–100. doi: https://doi.org/10.15408/kauniyah.v8i2.2694.

Taylor M, 2017. *Bats an Illustrated Guide to All Species* (T. Kitch, Ed.). United Kingdom: Susan Kelly.

Uca, Angrian R. 2018. Pemetaan Gua Kalibbong Aloa Kawasan Karst Pangkep. *Jurnal Sainsmat*, vol 7(2): 92–101. doi: https://doi.org/10.35580/sainsmat7273622018.

Welch JN, Beaulieu JM. 2018. Predicting extinction risk for data deficient bats. *Diversity*, vol 10(3): 1-15. doi: https://doi.org/10.3390/d10030063.

Wijayanti F, Maryanto I. 2017. Diversity and pattern of nest preference of bat species at bat-dwelling caves in Gombong Karst, Central Java, Indonesia. *Biodiversitas Journal of Biological Diversity*, vol 18(3): 864–874. doi: https://doi.org/10.13057/biodiv/d180302.