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Cave bats (Yangochiroptera and Yinpterochiroptera) in Gunung Sewu Geopark: Study of Karst Caves in Wonogiri Regency

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ABSTRACT

Indonesia is a country rich in biodiversity including flora and fauna. One of the high fauna diversity in Indonesia is the mammal. Some of these bats use karst caves as their roosting habitat. One of the karst areas in Indonesia is Gunung Sewu Karst. This study aims to learn more about the various bats that live in caves in the Gunung Sewu Geopark Area. This research was conducted in March-May 2023, in several caves located in the Gunung Sewu Geopark Area. Bats are caught using misnets and handnets. After they were captured, the bats were identified using Morphometry and the Shannon-Wiener index. Through another index, Margalef index, the bat diversity in the tree cave habitats was expressed, with a discovery that there are many different species. Based on the similarity index, bats were categorized again using cluster analysis and the unweighted pair-group method using arithmetic averages (UPGMA). The entire analysis was assisted with oftware PAST ver 4.13. The species recorded from the three caves in this study amounted to 8 species of bats belonging to 5 genera and 5 families. Sodong Cave is a habitat with the highest level of diversity and distribution of species. All three habitats have low similarity. The existence of endemic and vurnerable species is a priority in protecting caves as their habitat and Gunung Sewu karst macroecosystems. By preserving the habitat, all biodiversity in it will be preserved.

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1. INTRODUCTION

Indonesia is a country rich in biodiversity including flora and fauna. One of the high fauna diversity in Indonesia is the class of mammals, especially bats. There are as many as 239 species or about 24% of the total species of bats worldwide in Indonesia.. (Maryanto, et al., 2019).

Most bats use caves as their roosting habitat (Altringham and Senior, 2005). This cave is one of the very important perches for many bat species due to its physico-chemical parameters (Wijayanti et al., 2011; Prakarsa et al, 2023). Gunung Sewu is one of them as the best example of a tropical karst area and has been designated as a UNESCO World Geopark (Unesco, 2021) with a total area of 3,300 km2. Despite being a global geopark, the threat continues to increase due to increased land use in karst hills, population pressure in the highlands, excessive use of artificial fertilizers, and large mining expansion (Cahyadi et al., 2014; Prakarsa et al., 2022).

Bats have an important role for humans and ecosystems, for example bats as cave dwellers play an important role in energy circulation in caves because they produce guano, which is a source of energy for small animals in caves (Sridhar, et al., 2006; Prakarsa et al. 2021). In addition, these bats have a role in controlling agricultural pest insect populations and as pollinators (Cleveland et al., 2006; Wanger et al., 2014). Bat insectivores help control insect pests of agricultural crops. The types of feed preyed upon come from the Order Isoptera, Hymenoptera, Coleoptera, Lepidoptera, Orthoptera, Hemiptera, and Homoptera which are plant pest insects (Alyokin et al., 2022). This study aims to learn more about the various bats that live in caves in the Gunung Sewu Geopark Area, especially in the Wonogiri Regency area in an effort to provide basic information for habitat management in the future.

2. RESEARCH METHOD

This research was conducted in March-May 2023, in several caves located in the Gunung Sewu Geopark Area in the administrative area of Wonogiri Regency, Central Java. The caves consist of Sodong Cave, Gilap Cave and Putri Kencana Cave.

Figure 1. Location of Sodong Cave

Figure 2. Location of Gilap Cave

Figure 3. Location of Putri Kencana Cave

Three different caves were selected with a tunnel length determined based on stratified random sampling, namely: a) Sodong Cave with a passage length of >2,075 meters; b) Gilap Cave with a passage length of 50 meters; c) Putri Kencono Cave with a passage length of 100 meters.

Bat collection is carried out at 15.00-20.00 WIB using *mist nets* on the bat flight path around the mouth of the cave. *Hand nets* are used to collect bats perched in caves. Bats caught in the *mist net* are then transferred to the blacu bag. Bats identification was based on the combination of Morphometry and morphology which includes body weight (weight), head and body length (head and body), forearm (forearm), ear length (ear), tail length (tail), tibia length (tib), and hind leg length (hind foot) followingSuyanto (2001) and Huang et al., (2016).

The data obtained are then analyzed with the Species Diversity Index using the diversity index formula Shannon-Wiener (Bower dan Zar, 1997).

$$H' = -\sum \quad \frac{ni}{N} x In \frac{ni}{N}$$

H'= Indeks Keanekaragaman Shan-nonWienner
ni = number of individuals of the i-th species
N = number of individuals of the entire species

The value of the diversity index is used to determine the value of the type evenness index with the evenness index formula Shannon Evennes (Krebs, 1989).

$$E = \frac{H'}{In\, S}$$

E = Indeks Kemerataan Shannon Evenness
H' = Indeks keanekaragaman ShannonWienner
S = Number of Species

In addition, diversity is also calculated using the margalif index. The value of the Margalef Index will be greater as the wider the sample plots used, and the higher the diversity shown by the greater the value of species richnes (Boontawe, *et al*., 1995). The Margalef Index equation used is:

$$R1 = \frac{s\ -1'}{ln(N)}$$

R1= richnes Index
S = Number of species found
N = Total number of individuals

The Dominance Index is calculated based on the Simpson Index in Krebs (1989) using the formula:

$$C = \sum \quad \left[\frac{ni}{N^2}\right]$$

C = Dominance Index
ni = number of individuals of the i-th species
N = total number of individuals

Similarity Index (Bray-Curtis)
The Bray-Curtis Index is an index used to see the level of similarity between habitats

$$S\ jk = 100\ (1- (\Sigma\ (Yij – Yik)/ \Sigma\ (Yij + Yik))$$

Sjk = similarity index between j and k
Yij = number of first species in column j
Yjk = number of first species in column k

Base on similarity bats were categorized using cluster analysis and the unweighted pair-group method using arithmetic averages (UPGMA) (Sneath & Sokal 1973). Based on the Jaccard similarity index, bats were categorized using cluster analysis and the unweighted pairgroup method using arithmetic averages (UPGMA) (Sneath & Sokal 1973). All the analyses were performed using PAST Paleontological Statistics tool, ver. 4.13 (Hammer et al., 2001).

3. RESULTS AND DISCUSSION

Based on this study there are 8 species of bats belonging to 5 genera and 5 different families. Details of species are presented in (Table 1). The morphometric characteristics of each species are presented in Table 2.

Table 1. Bat species diversity in three species

Family	Genus	Species	IUCN	Cave		
Family				Gilap	Sodong	Putri Kencana
Hipposideridae	*Hipposideros*	*Hipposideros larvatus* (Gray, 1931)	LC	2	0	0
		Hipposideros atter	-	2	0	0
		Hipposideros diadema (Geoffroy, 1813)	LC	2	0	0
Vespertilionidae	*Myotis*	*Myotis muricola* (Gray, 1864)	LC	1	0	0
Rhinolophidae	*Rhinolophus*	*Rhinolophus canuti* (Thomas & Wroughton, 1909)	VU	1	5	0
Megadermatidae	*Megaderma*	*Megaderma spasma* (Linnaeus, 1758)	LC	0	0	3
Miniopteridae	*Miniopterus*	*Miniopterus fuliginosus*	-	5	0	0
		Miniopterus australis (Tommes, 1858)	LC	2	0	0
				15	5	3

Table 2. Morphometry of each bat species found in three caves

Species	Sex	Morfometri (mm)						
		1	2	3	4	5	6	7
H. larvatus	Male	13	49,1	51,8	14,65	25,7	17,47	7,2
H. ater	Male	5	33,7	38,2	16,3	24,65	14,9	48,5
	Female	6	36,1	37,7	11	18,6	11,85	3,2
H. diadema	Male	55,5	79,25	86,9	14,9	43,8	25,5	12,15
M. muricola	Female	13	36,5	35,2	11,4	38,8	15,2	7,8
R. canuti	Male	14	48,5	42,3	51,35	15,2	11,7	6,4
	Female	18	40,7	50,8	19,3	15,2	25,6	7,8
M. spasma	Male	24	54,2	55,5	32,3	43,2	29,7	12,1
	Female	26	55,2	54,9	33,6	35,7	29,1	15,4
M. fuliginosus	Male	14,25	42,55	46,05	7,91	38,18	20,1	6,9
	Female	16	44,4	45,5	22,5	53	17,85	7,5
M. australis	Male	5	31,9	32,4	7,1	35,3	12,65	38,5
	Female	5	30,2	36,6	2,8	17,1	2,7	42,05

1 = weight, 2 = head and body, 3 = forearm, 4 = ear, 5 = tail, 6 = tibia, 7 = hind foot.

a b c d e

Figure 4. Species found in all three cave habitats (documentation of 5 out of 8 species). **a.** R.canuti, **b.** M. spasma, **c.** H. diadema, **d.** H.ater, **e.** M. australis

The species *R. canuti* became the species with the largest number of individuals after *M. fuliginosus* found in all three caves. It even became a common species in Gilap Cave. This is different from the records of Ikranegara et al. (2014) and Prakarsa et al. (2022) which revealed that this species is an endemic species of Java which has quite rare encounters. Putri Kencama Cave is the only one inhabited by only one species, namely *M. spasma*. According to Prakarsa (2013), this species tends to inhabit caves as a single population.

The bat species found in this study were dominated by bats with LC (least concern) status *and only 1 species with VU* (vulnerable) status, namely *R. canuti*. One other species (*M. fuliginosus*) is not in the IUCN redlist database. This is possible due to a change in the name of a species that was previously included *in M. schreibersi* but was later identified as a distinct species in Asia as *M. fuliginosus* (Wilson and Mittermeier, 2019).

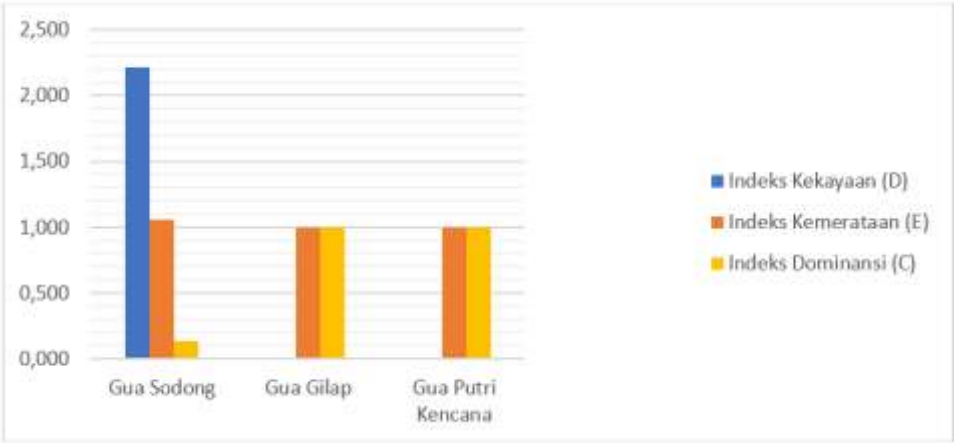

Figure 5. Comparison of Wealth Index, Equity Index, Diversity Index, and Dominance Index in Sodong Cave, Gilap Cave, and Putri Kencana Cave.

The Indonesian Karst Museum area, Wonogiri Regency, especially in Sodong Cave, Gilap Cave, and Putri Kencana Cave has a Species Diversity Index (Shannon-Wiener) value of 2,086, a Species Richness Index (Margalef) value of 2,233, a Species Evenness Index (Evenness) of 1,007, and a Dominance Index of 0.126. These figures show that the Sodong Cave, Gilap Cave, and Putri Kencana Cave areas have a moderate level of diversity, then have a low level of species richness, and an evenness index value that exceeds 1 indicates that an area has a balance between one group and another, then for the level of dominance itself is low because it is close to 0 which shows that in all three regions There tends to be no predominance of certain species.

When viewed from each cave species diversity index, Sodong Cave has the highest diversity value (2,002). The diversity of a community is determined by the number of species and individuals within it. If the community has many species with an even distribution, then species diversity will be high. This level of diversity will affect the stability of communities in the region (Sutrisna, *et al*., 2018).

The species richness index in Sodong Cave is also the highest when compared to the other two caves (2,216). Gua Gilap and Gua Putri Kencana both have a wealth level of 1. In contrast to the dominance index which shows that Gilap Cave and Putri Kencana Cave have a dominance level of 1 which means that in a population there tends to be dominance of one species, while Sodong Cave itself has a value of 0.133 which

means that in the cave there tends not to be dominance of one species. The comparison of the index between the 3 cave areas used as research sites can be seen in detail in Figure 5.

The evenness index value in the three caves both obtained an evenness level of 1, except for Sodong Cave (1,058). This difference in species evenness shows that each cave has a composition of the number of individuals in each different species. Evenness is an indicator of the presence of symptoms of dominance in each species in a community. The difference in evenness values between the species of each cave indicates that there are species that dominate. Gilap Cave and Putri Kencana Cave have an even value of 1 because each of these caves has species with each relatively similar number of individuals.

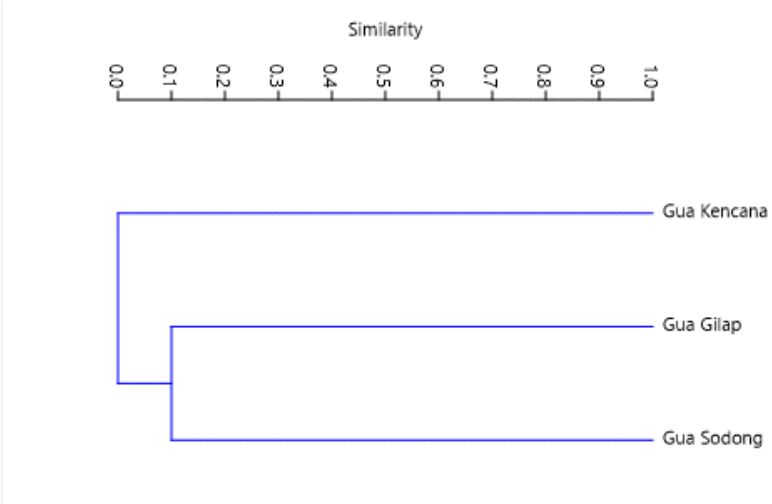

Figure 6. Dendogram Grouping Bat Distribution Habitat in Sodong Cave, Gilap Cave, and Putri Kencana Cave Based on the Bray Curtis Index.

The similarity index is used to show distribution patterns, assume habitat similarity, and provide an idea of differences in each place (Magurran, 2004). Only one similar species can be found in 2 of the 3 caves, R. *canuti* (Table 1). When viewed from the similarity of species found in each cave, Sodong Cave and Gilap Cave have the closest similarity with a value of 0.1 because there is 1 species that can be found in both caves, namely *R. canuti*. While Gua Putri Kencana has the furthest species similarity with a value of 0.0 in based on the similarity index value of Bray Curtis. The more the similarity index value of the result is close to 0, the bat equation from the cave is low. This is due to variations in physical, chemical, and interaction environmental conditions between species along the observation area, which allows the frequency and density of each species to also vary (Haneda *et al., 2013*). So from Figure 6 it can be said that the three cave habitats have low community types in common.

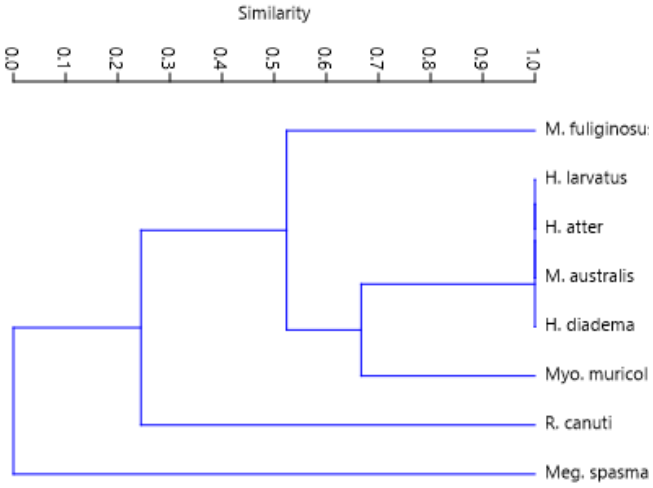

Figure 7. Dendrogram Grouping of Bat Species Based on Bray Curtis Similarity Index between All Three Habitats

Figure 7 Is a dendogram of grouping species based on habitat similarity. The species most distantly in common are *H. diadema* and *M. spasma.* While the closest species relationships, are seen in some species as seen in Figure 7. The similarity index is also an index to determine the similarity (proximity) of communities in several different locations based on the many species they have (Arifin, *et al.*, 2017).

Viewed from a conservation point of view, these three bat habitat caves should be preserved. Pressure due to declining habitat quality will be greater in animals that have conservation status, are endemic and/or only live in specific habitats (Maharadatunkamsi 2001; maharadatunkamsi, et al. 2015). Therefore, efforts to reduce the level of disturbance from human activities in and around habitats, and encourage the use of environmental services that prioritize conservation. and sustainable must be continuously improved.

4. CONCLUSION

The species recorded from the three caves in this study totaled eight bat species from five genera and five families. Sodong Cave is a habitat with the highest level of diversity and evenness of species. The three habitats have low similarity. The existence of these endemic and natural species is a priority in protecting the cave as a habitat and the Mount Sewu karst macroecosystem. By preserving the habitat, all biodiversity in it will be sustainable.

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