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Diversity of Bat Species in Gunung Tunak Nature Park, Central Lombok, West Nusa Tenggara

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Abstract. Research on the diversity of bat species in the Gunung Tunak Nature Tourism Park, Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara was conducted to determine the diversity of bat species (species richness, diversity, and evenness). Sampling of bats was carried out in three places, namely in ~~Cave~~cave, ~~Hill~~ hill and forest. The specimens were collected use trapping method by mist net ~~used in this research is the trapping method using a mist net~~. The results showed that~~, of the~~ 112 individuals of bats caught include to~~,~~ 4 species ~~of were belonging to the S~~suborder Megachiroptera and 1 species ~~of from members of the~~ suborder Microchinoptera. The suborder Megachiroptera consists of 5 species (*Cynopterus nusatenggara, Eonycteris speleae, Rousettus amplexicaudatus, Macroglossus minimus* and *Cynopterus horsfieldii* Gray). The suborder Microchiroptera consists of 1 species (*Hipposideros diadema)*. The ~~results of the~~ analysis data resulted ~~of~~ the highest Margalef Index ~~were found~~ in ~~the Hill~~ hill habitat ~~of~~ with 1.125 score and the lowest ~~was~~ in the forest habitat ~~of~~ with 0.780 score. ~~In the~~Based on Shannon Index, the highest index ~~value is~~measured in the ~~Cave~~ cave habitat ~~of~~ 1,481 score and the lowest score found ~~is in the F~~forest habitat ~~of~~ with 1,012. Furthermore, the Evenness Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the ~~Hil~~ hill habitat of 0.733. while the highest Simpson Index value is in the ~~Cave~~ cave habitat of 0.744 and the lowest is in the ~~Forest~~ forest habitat of 0.615. The results of ~~the analysis of the~~ community similarity index using the Jaccard Index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard Index value of 1, namely cave and ~~Hill~~ hill habitats. While the species similarity index based on the comparison of habitat types shows that, 4 groups form full species similarity which gets a score of 1 of them, group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus) and group 4 (R. amplexicaudatus* and *M. minimus).*

Key Word: *Diversity. Bats, Gunung Tunak Nature Park, Central Lombok, West Nusa Tenggara*.

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1. Introduction

In Indonesia, there are 238 species or 21% of bat species (Maryanto, Ibnu, Maharadatunkamsi, Anang Setiawan Achmadi, Sigit Wiantoro, Eko Sulistiadi, Masaaki Yoneda, Agustinus Suyanto, 2019) and ~~on the island of~~ Lombok island recorded 36 species of bats ~~, there are 36 recorded bat species~~ (Kitchener D. J., Boeadi., 2002)(Maryanto, Ibnu, Maharadatunkamsi, Anang Setiawan Achmadi, Sigit Wiantoro, Eko Sulistiadi, Masaaki Yoneda, Agustinus Suyanto, 2019). Biogeographically, the position of Lombok Island is very interesting to be studied because it is located on the side of Wallace's biogeographical line. The study of the biogeographic distribution pattern of the island of Lombok shows that the distribution pattern of fruit-eating and insectivorous bat species has a tendency that the existing bat species are species belonging to the large Sunda cluster and are different from the species in the P cluster. Sumbawa and the east. thus the ocean between Lombok Island and Sumbawa Island is a very important part of the Indonesian bat biogeography line (Maryanto et al., 2011)

Bats have a very important role in the survival of human life and the preservation of ecosystems. Nectarivorous bats play an important role in maintaining and regenerating tropical forests through pollen transfer over long distances (Law & Lean, 1999). The success of bat pollination and plant reproduction varies depending on the plant species (Quesada et al., 2004).

Although the role of bats for human life is classified as very important, bat populations around the world have decreased. One of the main causes of the decline in bat populations is habitat degradation (Agustinus Suyanto, 2001). The lack of public knowledge about the importance of bats in the ecological chain causes attention and efforts to conserve bat species are still relatively low (Soegiharto et al., 2010)

Gunung Tunak Natural Park which is administratively located in Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province has legally established its functional status as a Nature Tourism Park based on the Decree of the Minister of Forestry No. 439/Kpts-II/1997. The forest ecosystem of Mount Tunak is also a habitat for various types of animals, including the Gray Monkey (*Macaca fascicularis*), monitor lizard (*Varanus salvator*), python (*Phyton sp*) Pangolin (*Manis javanica*), snake (*Colubridae, spp*), lizard (*Mabouya spp*).), Jungle Fowl (*Gallus gallus*), Kepodang, Sparrow (*Lonchura sp.*), Kecial (*Zosterops chloris*), Alang-Alang lathe (*Centropus bengalensis*), and several bird species are protected under Government Regulation No. 7/1999 on Preservation of Plants and Animals Species ~~Animals~~, ~~namely~~ they are Honeysucking Lombok (*Linchmera lombokia*), King Shrimp (*Halcyon chloris*), Bondol Eagle (Heliatur /Indus), Gosong Bird (*Megapodius reinwartdtii*), Koakiau (*Philemon buceroides*), and Timor deer (*Cervus timoriensis*) (BKSDA, 2016)

Research on bats has been widely carried out on the island of Lombok such as Gale-gale Bangkang Cave in Prabu Village, Buwun Cave in Prabu Village, Semeti Cave in Mekar Sari Village, Tanjung Ringgit Cave (Fajri et al., 2014), (Siti Rabiatul Fajri, Gito Hadiprayitno, 2014), (Siti Rabiatul Fajri dan Sucika Armiani, 2015), (Fajri & Armiani, 2021). However, research on bats has never been done in the Gunung Tunak Nature Park. Based on the observations made, there are locations where bats perch are inhabited by hundreds or even thousands of bats. The location is at Teluk Ujung Beach. This beach is located in the Gunung Tunak Natural Park area which has 2 karsts located on the left and right of the beach. In the karst there is a cave, this cave can be passed if the coastal water recedes. The cave is inhabited by bats which are quite abundant. This study aims to analyze the level of bat species diversity (Species Richness Index, diversity, and evenness) and the similarity of bat communities between habitat types where bats perch in Gunung Tunak Nature Park.

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2. Materials and Method

Study Area

The research was conducted at the Gunung Tunak Nature Park which is geographically located at 08º53'30"-08º57'30" South Latitude and 116º22'00" - 116º24'00" East Longitude Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province with an area of 1,219.97 Ha.

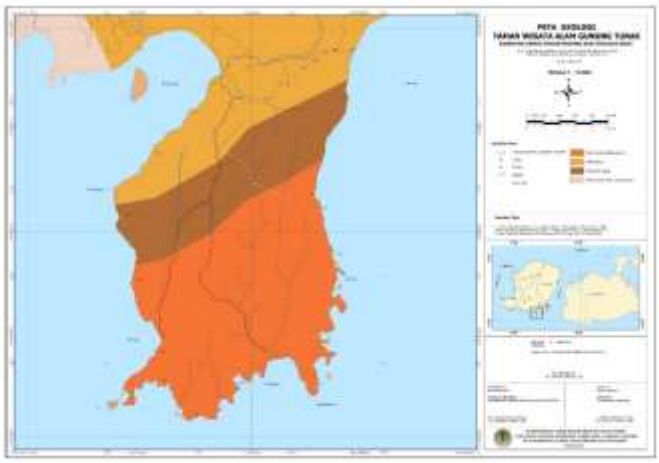

Figure 1. Study Area

Bat Sampling

The bat survey was carried out from March 2021 to July 2021 at the Gunung Tunak Nature Park. ~~Point~~ The location point of bat sampling consists of caves, hills, and forests. For bat sampling at the cave location, bats were caught using a mist net placed at the mouth of the cave. The arrests were made at 18:00-19:00 WITA. As for the sampling locations in hills and forests, bats were caught by installing three mist nets and harp traps on each land cover at three observation points at each location. The placement of mist-nets and harp traps was carried out purposively representing each habitat type. The installation of mist-net and harp-trap is carried out in the afternoon around 16:00 and inspections are carried out at 19:00-21:00 WITA. The bats caught were recorded by the name of the species, the number of individuals of each species, and the sex of each individual. Identification of bats refers to Suyanto and Kitchener (Agustinus Suyanto, 2001), (Kitchener D. J., Boeadi., 2002)

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Statistic Analisis

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The diversity of bat species in Gunung Tunak Nature Park was analyzed using the Margalef species richness index, the Shannon-Wiener species diversity index, the Pielou index, and the Simpson index. The Margalef species richness index equation is Dmg=(S–1)/ln(N). Notation S = number of bat species found, and N = total individuals of all species. Shannon-Wiener with the equation H'= – Spi.ln(pi) and pi=ni/N. Notation pi = the number of individuals of the i type, and N = the total number of individuals of all species. Species evenness was calculated using the Pielou index with the equation EPielou = H'/H'max = H'/ln(S). Notation H'= Shannon-Wiener species diversity index and S=total species found. An evenness index value close to one indicates that the number of individuals in a community is more evenly distributed across all species

found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned. Simpson index (Dominance Index) is calculated using the equation $D=\sum (ni/N)^2$ The dominance index ranges from 0 to 1. Where the smaller the Simpson index value indicates that no species dominates, the higher the dominance value indicates that certain species dominate (Kartono et al., 2017)

The similarity of the bat community was calculated using the Jaccard index (Cj) with the equation Cj = j/(a+b–j). Notation Cj = Jaccard index, a = number of species found in habitat a, b = number of species found in habitat b, and j = number of species found in both habitats. The Community Similarity Index is used to determine the similarity of bat species found in different habitats. The bat species similarity index was calculated using the Jaccard index (Cj). Analysis using Paleontological Statistical (PAST) (Dede Aulia Rahman, 2021).

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3. Results and Discussion

Bats Species

The number of individual bats caught in the Gunung Tunak Nature Park was 112 individuals with 6 species, namely *Cynopterus Nusatenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus*, and *Cynopterus horsfieldii* (Table 1).

Table 1. Types and Number of Individual Bats in Gunung Tunak Nature Park

Spesies Kelelawar	Cave	Hill	Forest	Total
Cynopterus nusatenggara	15	5	6	26
Eonycteris speleae	25	19	0	44
Hipposideros diadema	0	0	5	5
Rousettus amplexicaudatus	7	5	0	12
Macroglossus minimus	10	2	0	12
Cynopterus horsfieldii	7	4	2	13
Taxa_S	**5**	**5**	**3**	**13**
Individuals	**64**	**35**	**13**	**112**

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Based on the data in Table 1, it is stated that there were 44 individuals of *Eonycteris spelaea* caught, this number is much higher than other types of bats caught. *E. spelaea* was found at two sampling points, namely in the Cave and in the Bukit. *E. spelaea* in the IUCN Red List is included in the Least Concern (LC) category (Dave Waldien, 2020), but in this study, it is stated that *E. spelaea* has a fairly high number of individuals and is found in several types of habitats, such as caves and hills. *E. spelaea* has a fairly wide distribution, ranging from Malay-Indonesian, the South China Islands, and India (Francis, 2008). *E. spelaea* has also been found in plantation areas, primary and secondary forests, and mangrove forests (Francis, 2008). *E. spelaea* has very important benefits in creating a balance of plant ecosystems (Bumrungsri, S., Lang, D., Harrower, C., Sripaoraya, E., Kitpipit, K. and Racey, 2013), (Stewart & Dudash, 2017), (Nor Zalipah Mohamed, Mohd Sah Shahrul Anuar, 2016). *E. spelaea* has a function as a pollinator for several high-value

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plants such as durian (*Durio zibethinus*), and petai (*P. speciosa*) (Bumrungsri, S., A. Harbit, C. Benzie, K. Carmouche, K. Sridith, 2008), (Bumrungsri, S., E. Sripaoraya, T. Chongsiri, K. Sridith, 2009)

Hipposideros diadema is one of the suborder Microchiroptera bats found in the Gunung Tunak Nature Tourism Park. The meeting point is in the middle of the forest 500 meters from the deer breeding location. The number of arrests is only small, namely only 5 individuals. The morphology of *H. diadema* found in Gunung Tunak Nature Park was quite different from the *H. diadema* found previously. The body size is much larger, the bodyweight reaches 60-70 g and the forearm length of the wings reaches 75-90 mm. *H. diadema* is listed on the IUCN Red List as a species of Least Concern (LC). On the island of Lombok, the spread of *H. diadema* has been reported in several locations including Gale-gale Bangkang Cave, Tanjung Ringgit Cave and Buwun Cave (Siti Rabiatul Fajri, Gito Hadiprayitno, 2014), (Siti Rabiatul Fajri dan Sucika Armiani, 2015). While in Indonesia, the distribution is quite wide, including in Bintuni Bay, Papua (Lado et al., 2020) and South Sulawesi in Maros Pangkep Karst (Phadnis, 2017) While outside Indonesia, H. diadema has been reported to exist in Perak Malaysia (Nur Juliani et al., 2011), India (Aul et al., 2014)(Aul et al, 2014), and in caves in Bohol Island Philippines (Phelps et al., 2016)

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Bat Diversity

The diversity data in this study consisted of the species richness index (Margalef Index), species dominance index (Simpson Index), the diversity index (Shannon Index), and evenness index (Evenness Index).

Based on the results of the analysis, the Shannon Index states that the highest Shannon index value is at the sampling point carried out in the Cave with a value of H'= 1.481 and the lowest is at the sampling point in the forest with a value of H'= 1.012. In the Pielou Index, the highest value is at the sampling point in the forest with a value of E'= 0.917 and the lowest is at the sampling point in the hills with a value of E'= 0.733. In the Simpson Index the highest value is at the sampling point conducted in the cave with a value of D = 0.744 and the lowest is at the sampling point in the forest with a value of D = 0.615, and the last is the results of the analysis of the Margalef Index, the highest Margalef Index value is at the point Sampling was carried out in the hills with a value of R = 1.125 and the lowest was at the sampling point in the forest with a value of R = 0.780 (Figure 2).

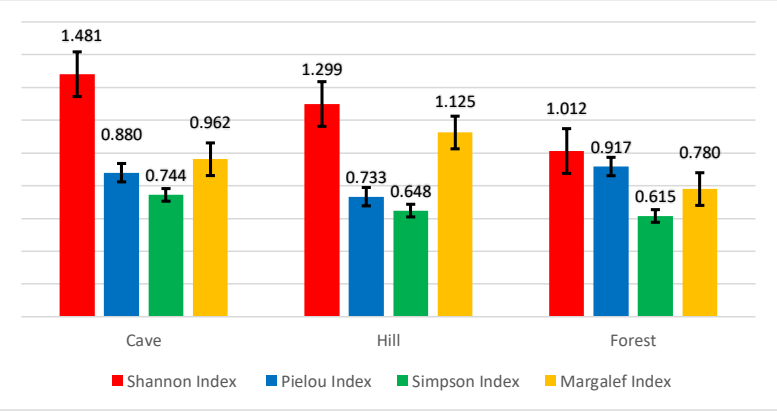

Figure 2. Diversity Index

Based on the research results shown in Figure 2, it is stated that the Shannon Index in the cave habitat is higher than in other habitats. This could be because the number of species richness that inhabits the cave is higher than in other habitats. In addition, the number of individuals caught is also higher. Bats are more

likely to choose cave habitats than other habitats. The stable and humid conditions of the cave cause many species of bats to choose to roost in the cave. The presence of high bats in a cave can benefit bats from one another because the humid and cold conditions of the cave will make the microclimate of the cave stable (Siti Rabiatul Fajri, 2016). Another advantage that is obtained when bats live in large colonies is that according to (Zukal J, 2005) some of the advantages of living in colonies are the transfer of information, safety to predators, reproductive success, and thermoregulation. The highest diversity in the cave habitat is also due to the large variety of cave conditions. In the cave, many spaces allow a wide variety of species to inhabit the available space. States that each type of bat will choose a different nest or perch according to environmental conditions that suit their needs and the more variations in the condition of the cave, the more variations in the types of bats that inhabit the cave (Wijayanti & Maryanto, 2017)

While in the Pielou Index, the evenness value that is close to number one is found in forest habitats, which is 0.917. This is because in this observation only one species was found in the forest habitat. Evenness can change if the species found in the habitat is more than one species. The evenness index value close to the value of one indicates that the number of individuals in a community is more evenly distributed across all species found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned. The Simpson Index (Dominance Index) shows the index value below the number one ranging from 0 to 0.7. Thus, the dominance index in the Gunung Tunak natural park shows that there are no dominant species in that habitat.

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Community Similarities

Community similarity was analyzed using the Jaccard similarity index. There are two types of analysis carried out in this study, namely the habitat use similarity index (Table 2) and the species similarity index in each habitat (Table 3). The Jaccard similarity index has a value equal to 1 if there is full equality. The results of the analysis of the community similarity index show that there is one group of habitat types that have a Jaccard similarity index value equal to 1, namely forest and hill habitats.

Table 2. Community Similarity Index Value

	Cave	Hill	Forest
Cave	1	1	0.333
Hill		1	0.333
Forest			1

Based on the results in Table 2, it is stated that the bat communities in caves and hills resulted in a Jaccard similarity index value equal to 1. It means that these two habitat types have full community similarities. This is because there are two species of the same bat found in both habitats. The two species are *Eonycteris speleae* and *Cynopterus nusatenggara*. However, stated that the grouping of species in a habitat does not only depend on the similarity of the species that inhabit the habitat, but the similarity of habitat environmental factors also plays a role in determining the habitat of an organism (Siti Rabiatul Fajri, 2016) The following are the results of the cluster analysis formed in Figure 3 below.

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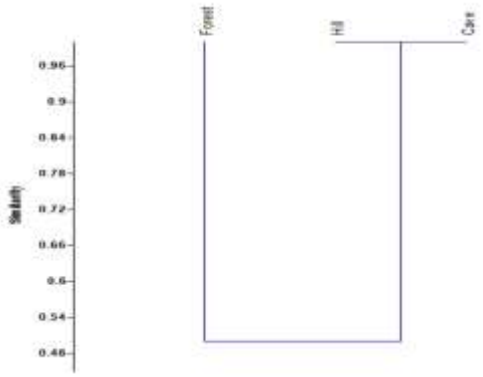

Gambar 3. Dendogram Community similarity

Burkhalter mention that species richness and relative abundance are some of the important attributes of an ecosystem and can be a marker in a community (Burkhalter, J. C., Moon, D. C., Rossi, 2013). However, Chao stated that the Jaccard community similarity index was based on the presence or absence of the same species in the habitat being compared and did not consider the abundance of species in a habitat (Chao, A., Jost, L., Chiang, S. C., Jiang, Y. H., Chazdon, 2008).

Table 3. Species Similarity Index

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	C.nusatenggara	*E.speleae*	*H.diadema*	*R.amplexicaudatus*	*M.minimus*	*C.horsfieldii*
C.nusatenggara	1	0.667	0.333	0.667	0.667	1
E.speleae		1	0.000	1	1	0.667
H.diadema			1	0.000	0.000	0.333
R.amplexicaudatus				1	1	0.667
M.minimus					1	0.667
C.horsfieldii						1

While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity that get scores including, group 1 (*C.nusatenggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*). There are several factors that cause full species similarity, including the first because the 4 groups formed tend to choose the same habitat. Both types of food are the same, the four groups are both fruit eaters. The following dendrogram is formed in Figure 4 below.

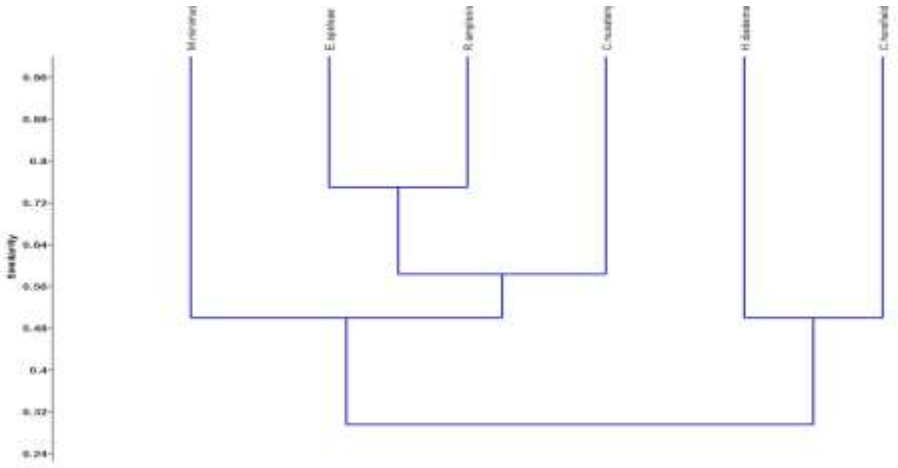

Figure 4. Species Similarity Dendrogram

4. Conclusion

The results showed that, based on 112 individual bats caught in Gunung Tunak Nature Tourism Park, there were 6 species (*Cynopterus Nusantenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus*, and *Cynopterus horsfieldii*). The results of the analysis of the highest margalef index were found in the Hill habitat of 1,125 and the lowest was in the forest habitat of 0.780. In the Shannon Index, the highest index value is in the Cave habitat of 1,481 and the lowest is in the forest habitat of 1,012. Furthermore, the Pielou Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the Hil habitat of 0.733. while the highest Simpson index value is in the Cave habitat of 0.744 and the lowest is in the forest habitat of 0.615. The results of the analysis of the community similarity index using the Jaccard index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard index value of 1, namely cave and hill habitats. While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity which gets a score of 1 of them, group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*).

Acknowledgment

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Diversity of Bat Species in Gunung Tunak Nature Park, Central Lombok, West Nusa Tenggara

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Abstract. Research on the diversity of bat species in the Gunung Tunak Nature Tourism Park, Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara was conducted to determine the diversity of bat species (species richness, diversity, and evenness). Sampling of the bats was carried out in three places, namely in Cave, Hill and forest. The method used in this research is the trapping method using a mist net. The results showed that, of the 112 individual bats caught, 4 species were belonging to the Suborder Megachiroptera and 1 species from members of the suborder Microchinoptera. The suborder Megachiroptera consists of 5 species (*Cynopterus nusatenggara, Eonycteris speleae, Rousettus amplexicaudatus, Macroglossus minimus* and *Cynopterus horsfieldii* Gray). The suborder Microchiroptera consists of 1 species (*Hipposideros diadema)*. The results of the analysis of the highest Margalef Index were found in the Hill habitat of 1.125 and the lowest was in the forest habitat of 0.780. In the Shannon Index, the highest index value is in the Cave habitat of 1,481 and the lowest is in the Forest habitat of 1,012. Furthermore, the Evenness Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the Hil habitat of 0.733. while the highest Simpson Index value is in the Cave habitat of 0.744 and the lowest is in the Forest habitat of 0.615. The results of the analysis of the community similarity index using the Jaccard Index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard Index value of 1, namely cave and Hill habitats. While the species similarity index based on the comparison of habitat types shows that, 4 groups form full species similarity which gets a score of 1 of them, group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus) and group 4 (R. amplexicaudatus* and *M. minimus).*

Key Word: *Diversity. Bats, Gunung Tunak Nature Park, Central Lombok, West Nusa Tenggara*.

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1. Introduction

In Indonesia, there are 238 species or 21% of bat species (Maryanto, Ibnu, Maharadatunkamsi, Anang Setiawan Achmadi, Sigit Wiantoro, Eko Sulistiadi, Masaaki Yoneda, Agustinus Suyanto, 2019) and on the island of Lombok, there are 36 recorded bat species (Kitchener D. J., Boeadi., 2002)(Maryanto, Ibnu, Maharadatunkamsi, Anang Setiawan Achmadi, Sigit Wiantoro, Eko Sulistiadi, Masaaki Yoneda, Agustinus Suyanto, 2019). Biogeographically, the position of Lombok Island is very interesting to be studied because it is located on the side of Wallace's biogeographical line. The study of the biogeographic distribution pattern of the island of Lombok shows that the distribution pattern of fruit-eating and insectivorous bat species has a tendency that the existing bat species are species belonging to the large Sunda cluster and are different from the species in the P cluster. Sumbawa and the east. thus the ocean between Lombok Island and Sumbawa Island is a very important part of the Indonesian bat biogeography line (Maryanto et al., 2011)

Bats have a very important role in the survival of human life and the preservation of ecosystems. Nectarivorous bats play an important role in maintaining and regenerating tropical forests through pollen transfer over long distances (Law & Lean, 1999). The success of bat pollination and plant reproduction varies depending on the plant species (Quesada et al., 2004).

Although the role of bats for human life is classified as very important, bat populations around the world have decreased. One of the main causes of the decline in bat populations is habitat degradation (Agustinus Suyanto, 2001). The lack of public knowledge about the importance of bats in the ecological chain causes attention and efforts to conserve bat species are still relatively low (Soegiharto et al., 2010)

Gunung Tunak Natural Park which is administratively located in Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province has legally established its functional status as a Nature Tourism Park based on the Decree of the Minister of Forestry No. 439/Kpts-II/1997. The forest ecosystem of Mount Tunak is also a habitat for various types of animals, including the Gray Monkey (*Macaca fascicularis*), monitor lizard (*Varanus salvator*), python (*Phyton sp*) Pangolin (*Manis javanica*), snake (*Colubridae, spp*), lizard (*Mabouya spp*).), Jungle Fowl (*Gallus gallus*), Kepodang, Sparrow (*Lonchura sp.*), Kecial (*Zosterops chloris*), Alang-Alang lathe (*Centropus bengalensis*), and several bird species are protected under Government Regulation No. 7/1999 on Preservation of Plant and Species Animals, namely Honeysucking Lombok (*Linchmera lombokia*), King Shrimp (*Halcyon chloris*), Bondol Eagle (Heliatur /Indus), Gosong Bird (*Megapodius reinwartdtii*), Koakiau (*Philemon buceroides*), Timor deer (*Cervus timoriensis*) (BKSDA, 2016)

Research on bats has been widely carried out on the island of Lombok such as Gale-gale Bangkang Cave in Prabu Village, Buwun Cave in Prabu Village, Semeti Cave in Mekar Sari Village, Tanjung Ringgit Cave (Fajri et al., 2014), (Siti Rabiatul Fajri, Gito Hadiprayitno, 2014), (Siti Rabiatul Fajri dan Sucika Armiani, 2015), (Fajri & Armiani, 2021). However, research on bats has never been done in the Gunung Tunak Nature Park. Based on the observations made, there are locations where bats perch are inhabited by hundreds or even thousands of bats. The location is at Teluk Ujung Beach. This beach is located in the Gunung Tunak Natural Park area which has 2 karsts located on the left and right of the beach. In the karst there is a cave, this cave can be passed if the coastal water recedes. The cave is inhabited by bats which are quite abundant. This study aims to analyze the level of bat species diversity (Species Richness Index, diversity, and evenness) and the similarity of bat communities between habitat types where bats perch in Gunung Tunak Nature Park.

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2. Materials and Method

Study Area

The research was conducted at the Gunung Tunak Nature Park which is geographically located at 08º53'30"-08°57'30" South Latitude and 116º22'00" - 116º24'00" East Longitude Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province with an area of 1,219.97 Ha.

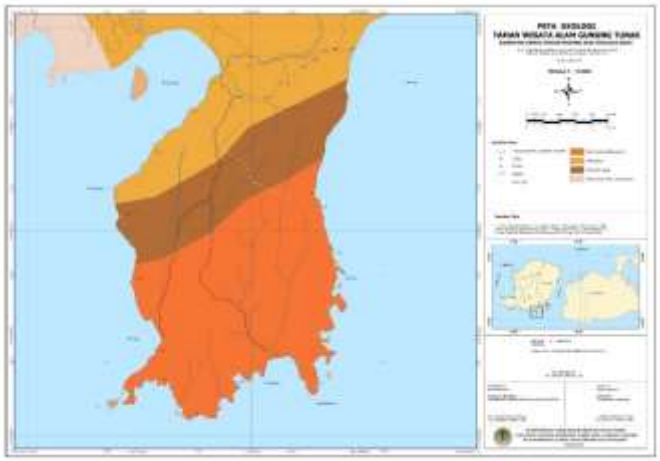

Figure 1. Study Area

Bat Sampling

The bat survey was carried out from March 2021 to July 2021 at the Gunung Tunak Nature Park. Point The location of bat sampling consists of caves, hills, and forests. For bat sampling at the cave location, bats were caught using a mist net placed at the mouth of the cave. The arrests were made at 18:00-19:00 WITA. As for the sampling locations in hills and forests, bats were caught by installing three mist nets and harp traps on each land cover at three observation points at each location. The placement of mist-nets and harp traps was carried out purposively representing each habitat type. The installation of mist-net and harp-trap is carried out in the afternoon around 16:00 and inspections are carried out at 19:00-21:00 WITA. The bats caught were recorded by the name of the species, the number of individuals of each species, and the sex of each individual. Identification of bats refers to Suyanto and Kitchener (Agustinus Suyanto, 2001), (Kitchener D. J., Boeadi., 2002)

Statistic Analisis

The diversity of bat species in Gunung Tunak Nature Park was analyzed using the Margalef species richness index, the Shannon-Wiener species diversity index, the Pielou index, and the Simpson index. The Margalef species richness index equation is Dmg=(S–1)/ln(N). Notation S = number of bat species found, and N = total individuals of all species. Shannon-Wiener with the equation H'= – Spi.ln(pi) and pi=ni/N. Notation pi = the number of individuals of the i type, and N = the total number of individuals of all species. Species evenness was calculated using the Pielou index with the equation EPielou = H'/H'max = H'/ln(S). Notation H'= Shannon-Wiener species diversity index and S=total species found. An evenness index value close to one indicates that the number of individuals in a community is more evenly distributed across all species found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned. Simpson index (Dominance

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Index) is calculated using the equation $D=\sum (ni/N)^2$ The dominance index ranges from 0 to 1. Where the smaller the Simpson index value indicates that no species dominates, the higher the dominance value indicates that certain species dominate (Kartono et al., 2017)

The similarity of the bat community was calculated using the Jaccard index (Cj) with the equation Cj = j/(a+b–j). Notation Cj = Jaccard index, a = number of species found in habitat a, b = number of species found in habitat b, and j = number of species found in both habitats. The Community Similarity Index is used to determine the similarity of bat species found in different habitats. The bat species similarity index was calculated using the Jaccard index (Cj). Analysis using Paleontological Statistical (PAST) (Dede Aulia Rahman, 2021).

3. Results and Discussion

Bats Species

The number of individual bats caught in the Gunung Tunak Nature Park was 112 individuals with 6 species, namely *Cynopterus Nusatenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus*, and *Cynopterus horsfieldii* (Table 1).

Table 1. Types and Number of Individual Bats in Gunung Tunak Nature Park

Spesies Kelelawar	Cave	Hill	Forest	Total
Cynopterus nusatenggara	15	5	6	26
Eonycteris speleae	25	19	0	44
Hipposideros diadema	0	0	5	5
Rousettus amplexicaudatus	7	5	0	12
Macroglossus minimus	10	2	0	12
Cynopterus horsfieldii	7	4	2	13
Taxa_S	**5**	**5**	**3**	**13**
Individuals	**64**	**35**	**13**	**112**

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Based on the data in Table 1, it is stated that there were 44 individuals of *Eonycteris spelaea* caught, this number is much higher than other types of bats caught. *E. spelaea* was found at two sampling points, namely in the Cave and in the Bukit. *E. spelaea* in the IUCN Red List is included in the Least Concern (LC) category (Dave Waldien, 2020), but in this study, it is stated that *E. spelaea* has a fairly high number of individuals and is found in several types of habitats, such as caves and hills. *E. spelaea* has a fairly wide distribution, ranging from Malay-Indonesian, the South China Islands, and India (Francis, 2008). *E. spelaea* has also been found in plantation areas, primary and secondary forests, and mangrove forests (Francis, 2008). *E. spelaea* has very important benefits in creating a balance of plant ecosystems (Bumrungsri, S., Lang, D., Harrower, C., Sripaoraya, E., Kitpipit, K. and Racey, 2013), (Stewart & Dudash, 2017), (Nor Zalipah Mohamed, Mohd Sah Shahrul Anuar, 2016). *E. spelaea* has a function as a pollinator for several high-value plants such as durian (*Durio zibethinus*), and petai (*P. speciosa*) (Bumrungsri, S., A. Harbit, C. Benzie, K. Carmouche, K. Sridith, 2008), (Bumrungsri, S., E. Sripaoraya, T. Chongsiri, K. Sridith, 2009)

Hipposideros diadema is one of the suborder Microchiroptera bats found in the Gunung Tunak Nature Tourism Park. The meeting point is in the middle of the forest 500 meters from the deer breeding location. The number of arrests is only small, namely only 5 individuals. The morphology of *H. diadema* found in Gunung Tunak Nature Park was quite different from the *H. diadema* found previously. The body size is much larger, the bodyweight reaches 60-70 g and the forearm length of the wings reaches 75-90 mm. *H. diadema* is listed on the IUCN Red List as a species of Least Concern (LC). On the island of Lombok, the spread of *H. diadema* has been reported in several locations including Gale-gale Bangkang Cave, Tanjung Ringgit Cave and Buwun Cave (Siti Rabiatul Fajri, Gito Hadiprayitno, 2014), (Siti Rabiatul Fajri dan Sucika Armiani, 2015). While in Indonesia, the distribution is quite wide, including in Bintuni Bay, Papua (Lado et al., 2020) and South Sulawesi in Maros Pangkep Karst (Phadnis, 2017) While outside Indonesia, H. diadema has been reported to exist in Perak Malaysia (Nur Juliani et al., 2011), India (Aul et al., 2014)(Aul et al, 2014), and in caves in Bohol Island Philippines (Phelps et al., 2016)

Bat Diversity

The diversity data in this study consisted of the species richness index (Margalef Index), species dominance index (Simpson Index), the diversity index (Shannon Index), and evenness index (Evenness Index).

Based on the results of the analysis, the Shannon Index states that the highest Shannon index value is at the sampling point carried out in the Cave with a value of H'= 1.481 and the lowest is at the sampling point in the forest with a value of H'= 1.012. In the Pielou Index, the highest value is at the sampling point in the forest with a value of E'= 0.917 and the lowest is at the sampling point in the hills with a value of E'= 0.733. In the Simpson Index the highest value is at the sampling point conducted in the cave with a value of D = 0.744 and the lowest is at the sampling point in the forest with a value of D = 0.615, and the last is the results of the analysis of the Margalef Index, the highest Margalef Index value is at the point Sampling was carried out in the hills with a value of R = 1.125 and the lowest was at the sampling point in the forest with a value of R = 0.780 (Figure 2).

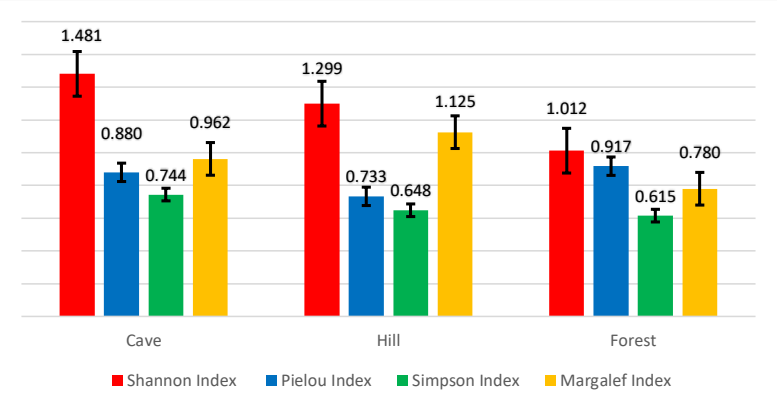

Figure 2. Diversity Index

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Based on the research results shown in Figure 2, it is stated that the Shannon Index in the cave habitat is higher than in other habitats. This could be because the number of species richness that inhabits the cave is higher than in other habitats. In addition, the number of individuals caught is also higher. Bats are more likely to choose cave habitats than other habitats. The stable and humid conditions of the cave cause many species of bats to choose to roost in the cave. The presence of high bats in a cave can benefit bats from one

another because the humid and cold conditions of the cave will make the microclimate of the cave stable (Siti Rabiatul Fajri, 2016). Another advantage that is obtained when bats live in large colonies is that according to (Zukal J, 2005) some of the advantages of living in colonies are the transfer of information, safety to predators, reproductive success, and thermoregulation. The highest diversity in the cave habitat is also due to the large variety of cave conditions. In the cave, many spaces allow a wide variety of species to inhabit the available space. States that each type of bat will choose a different nest or perch according to environmental conditions that suit their needs and the more variations in the condition of the cave, the more variations in the types of bats that inhabit the cave (Wijayanti & Maryanto, 2017)

While in the Pielou Index, the evenness value that is close to number one is found in forest habitats, which is 0.917. This is because in this observation only one species was found in the forest habitat. Evenness can change if the species found in the habitat is more than one species. The evenness index value close to the value of one indicates that the number of individuals in a community is more evenly distributed across all species found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned. The Simpson Index (Dominance Index) shows the index value below the number one ranging from 0 to 0.7. Thus, the dominance index in the Gunung Tunak natural park shows that there are no dominant species in that habitat.

Community Similarities

Community similarity was analyzed using the Jaccard similarity index. There are two types of analysis carried out in this study, namely the habitat use similarity index (Table 2) and the species similarity index in each habitat (Table 3). The Jaccard similarity index has a value equal to 1 if there is full equality. The results of the analysis of the community similarity index show that there is one group of habitat types that have a Jaccard similarity index value equal to 1, namely forest and hill habitats.

Table 2. Community Similarity Index Value

	Cave	Hill	Forest
Cave	1	1	0.333
Hill		1	0.333
Forest			1

Based on the results in Table 2, it is stated that the bat communities in caves and hills resulted in a Jaccard similarity index value equal to 1. It means that these two habitat types have full community similarities. This is because there are two species of the same bat found in both habitats. The two species are *Eonycteris speleae* and *Cynopterus nusatenggara*. However, stated that the grouping of species in a habitat does not only depend on the similarity of the species that inhabit the habitat, but the similarity of habitat environmental factors also plays a role in determining the habitat of an organism (Siti Rabiatul Fajri, 2016) The following are the results of the cluster analysis formed in Figure 3 below.

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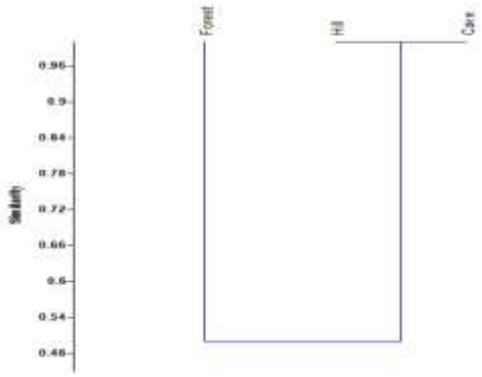

Gambar 3. Dendogram Community similarity

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Burkhalter mention that species richness and relative abundance are some of the important attributes of an ecosystem and can be a marker in a community (Burkhalter, J. C., Moon, D. C., Rossi, 2013). However, Chao stated that the Jaccard community similarity index was based on the presence or absence of the same species in the habitat being compared and did not consider the abundance of species in a habitat (Chao, A., Jost, L., Chiang, S. C., Jiang, Y. H., Chazdon, 2008).

Table 3. Species Similarity Index

	C.nusatenggara	*E.speleae*	*H.diadema*	*R.amplexicaudatus*	*M.minimus*	*C.horsfieldii*
C.nusatenggara	1	0.667	0.333	0.667	0.667	1
E.speleae		1	0.000	1	1	0.667
H.diadema			1	0.000	0.000	0.333
R.amplexicaudatus				1	1	0.667
M.minimus					1	0.667
C.horsfieldii						1

While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity that get scores including, group 1 (*C.nusatenggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*). There are several factors that cause full species similarity, including the first because the 4 groups formed tend to choose the same habitat. Both types of food are the same, the four groups are both fruit eaters. The following dendrogram is formed in Figure 4 below.

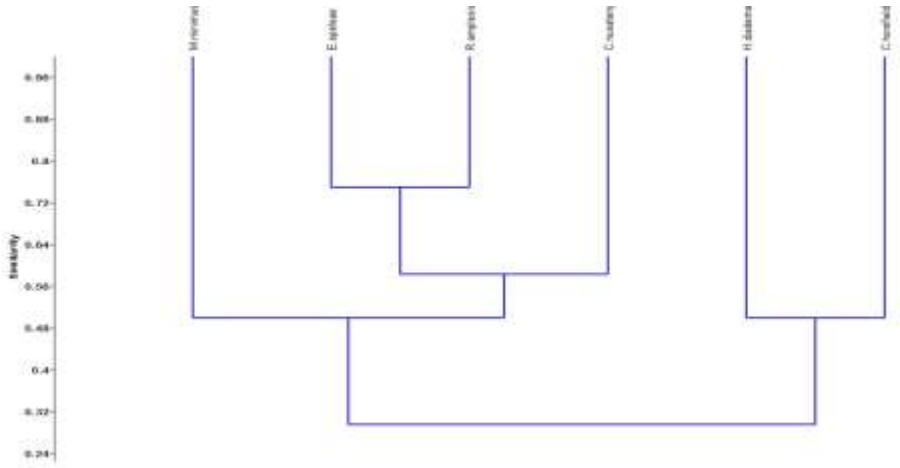

Figure 4. Species Similarity Dendrogram

4. Conclusion

The results showed that, based on 112 individual bats caught in Gunung Tunak Nature Tourism Park, there were 6 species (*Cynopterus Nusantenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus*, and *Cynopterus horsfieldii*). The results of the analysis of the highest margalef index were found in the Hill habitat of 1,125 and the lowest was in the forest habitat of 0.780. In the Shannon Index, the highest index value is in the Cave habitat of 1,481 and the lowest is in the forest habitat of 1,012. Furthermore, the Pielou Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the Hil habitat of 0.733. while the highest Simpson index value is in the Cave habitat of 0.744 and the lowest is in the forest habitat of 0.615. The results of the analysis of the community similarity index using the Jaccard index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard index value of 1, namely cave and hill habitats. While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity which gets a score of 1 of them, group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*).

Acknowledgment

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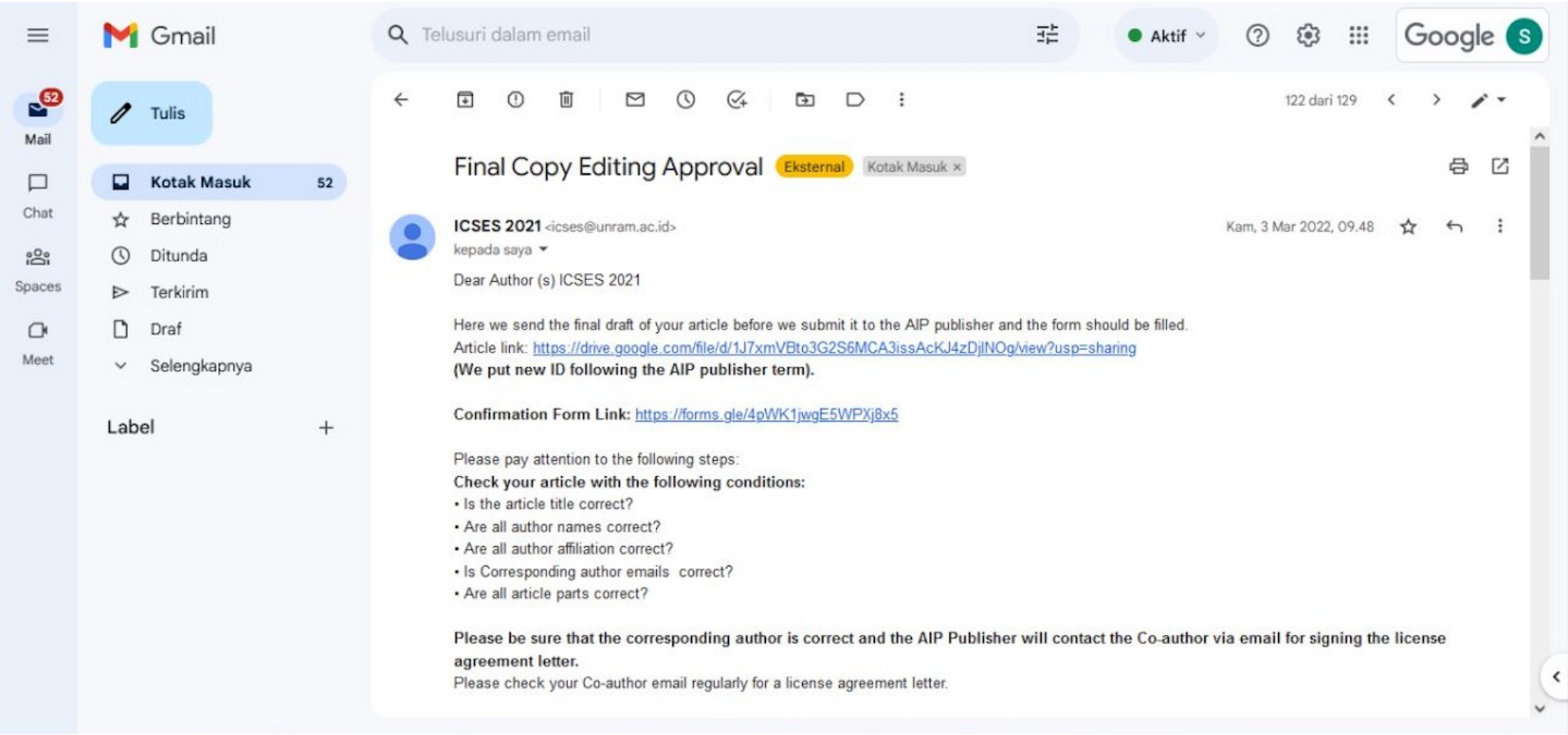
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Diversity of Bat Species in Gunung Tunak Nature Tourism Park, Central Lombok, West Nusa Tenggara

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Abstract. Research on the diversity of bat species in the Gunung Tunak Nature Tourism Park, Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara was conducted to determine the diversity of bat species (species richness, diversity, and evenness). Sampling of bats was carried out in three places, namely in cave, hill and forest. The specimens were collected use trapping method by mist net. The results showed that 112 individuals of bats caught include to 5 species of suborder Megachiroptera and 1 species of suborder Microchinoptera. The suborder Megachiroptera consists of 5 species (*Cynopterus nusatenggara, Eonycteris speleae, Rousettus amplexicaudatus, Macroglossus minimus* and *Cynopterus horsfieldii* Gray). The suborder Microchiroptera consists of 1 species (*Hipposideros diadema)*. The analysis data resulted the highest Margalef Index in hill habitat with 1.125 score and the lowest in the forest habitat with 0.780 score. Based on Shannon Index, the highest index measured in the cave habitat 1,481 score and the lowest score found forest habitat with 1,012. Furthermore, the Evenness Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the hill habitat of 0.733. While the highest Simpson Index value is in the cave habitat of 0.744 and the lowest is in the forest habitat of 0.615. The results of community similarity index using the Jaccard Index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard Index value of 1, namely cave and hill habitats. Meanwhile, the species similarity index value based on the comparison of habitat types shows that, there are 4 groups of species that make up the full species similarity with a score of 1 of them; group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*).

INTRODUCTION

In Indonesia, there are 238 species or 21% of bat species [1] and Lombok island recorded 36 species of bats [2]; [1]. Biogeographically, the position of Lombok Island is very interesting to be studied because it is located on the side of Wallace's biogeographical line. The pattern of biogeographic distribution of the island of Lombok shows that the distribution pattern of fruit-eating and insect-eating bats has a tendency that the types of bats found on the island of Lombok are species belonging to the Sunda cluster and significantly different from the species found on the Sumbawa island and the east again. Thus it can be concluded, bats that are in the ocean between the Lombok island and Sumbawa islands are a very important part of the Indonesian bat biogeography line. [3].

Bats have a very important role in the survival of human life and the preservation of ecosystems. Nectarivorous bats play an important role in maintaining and regenerating tropical forests through pollen transfer over long distances [4]. The success of bat pollination and plant reproduction varies depending on the plant species [5].

Although the role of bats for human life is classified as very important, bat populations around the world have decreased. One of the main causes of the decline in bat populations is habitat degradation [6]. The lack of public knowledge about the importance of bats in the ecological chain causes attention and efforts to conserve bat species are still relatively low [7].

Gunung Tunak Natural Tourism Park which is administratively located in Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province has legally established its functional status as a Nature Tourism Park based on the Decree of the Minister of Forestry No. 439/Kpts-II/1997. The forest ecosystem of Mount Tunak is also a habitat for various types of animals, including the Gray Monkey (*Macaca fascicularis*), monitor lizard (*Varanus salvator*), python (*Phyton sp*) Pangolin (*Manis javanica*), snake (*Colubridae, spp*), lizard (*Mabouya spp*).), Jungle Fowl (*Gallus gallus*), Kepodang, Sparrow (*Lonchura sp.*), Kecial (*Zosterops chloris*), Alang-Alang lathe (*Centropus bengalensis*), and several bird species are protected under Government Regulation No. 7/1999 on Preservation of Plants and Animals Species, they are Honeysucking Lombok (*Linchmera lombokia*), King Shrimp (*Halcyon chloris*), Bondol Eagle (Heliatur /Indus), Gosong Bird (*Megapodius reinwartdtii*), Koakiau (*Philemon buceroides*), and Timor deer (*Cervus timoriensis*) [8].

Research on bats has been widely carried out on the island of Lombok such as Gale-gale Bangkang Cave in Prabu Village, Buwun Cave in Prabu Village, Semeti Cave in Mekar Sari Village, Tanjung Ringgit Cave [9]; [10]; [11]; [12]. However, research on bats has never been done in the Gunung Tunak Nature Park. Based on the observations made, there are locations where bats perch are inhabited by hundreds or even thousands of bats. The location is at Teluk Ujung Beach. This beach is located in the Gunung Tunak Natural Tourism Park area which has 2 karsts located on the left and right of the beach. In the karst there is a cave, this cave can be passed if the coastal water recedes. The cave is inhabited by bats which are quite abundant. This study aims to analyze the level of bat species diversity (Species Richness Index, diversity, and evenness) and the similarity of bat communities between habitat types where bats perch in Gunung Tunak Nature Tourism Park.

MATERIALS AND METHOD

Study Area

The research was conducted at the Gunung Tunak Nature Tourism Park which is geographically located at 08º53'30"- 08º57'30" South Latitude and 116º22'00" - 116º24'00" East Longitude Mertak Village, Pujut District, Central Lombok Regency, West Nusa Tenggara Province with an area of 1,219.97 Ha.

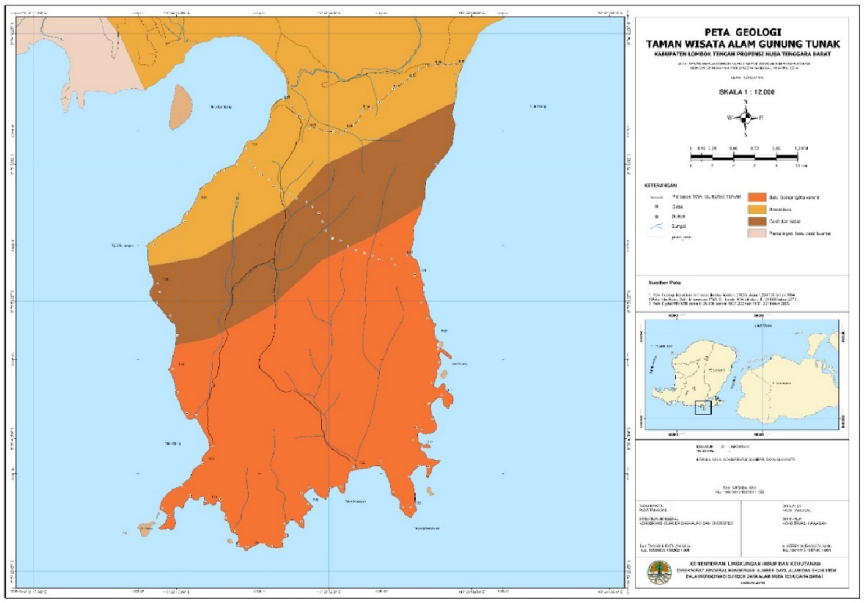

FIGURE 1. Study Area

Bat Sampling

The bat survey was carried out from March 2021 to July 2021 at the Gunung Tunak Nature Tourism Park. The location point of bat sampling consists of caves, hills, and forests. For bat sampling at the cave location, bats were caught using a mist net placed at the mouth of the cave. The arrests were made at 18:00-19:00 WITA. As for the sampling locations in hills and forests, bats were caught by installing three mist nets and harp traps on each land cover at three observation points at each location. The placement of mist-nets and harp traps was carried out purposively representing each habitat type. The installation of mist-net and harp-trap is carried out in the afternoon around 16:00 and inspections are carried out at 19:00-21:00 WITA. The bats caught were recorded by the name of the species, the number of individuals of each species, and the sex of each individual. Identification of bats refers to Suyanto and Kitchener [6]; [2]

Statistical Analysis

The diversity of bat species in Gunung Tunak Nature Park was analyzed using the Margalef species richness index, the Shannon-Wiener species diversity index, the Pielou index, and the Simpson index. The Margalef species richness index equation is

$$\text{Dmg} = \frac{(S-1)}{\ln(N)} \quad (1)$$

Notation S = number of bat species found, and N = total individuals of all species.
Shannon-Wiener with the equation is

$$\text{H}' = -\,(pi)\ln\,(pi) \quad (2)$$

$$\text{pi} = \frac{ni}{N} \quad (3)$$

Notation pi = the number of individuals of the i type, and N = the total number of individuals of all species.
Species evenness was calculated using the Pielou index with the equation is

$$\text{E}_{\text{Pielou}} = \frac{H'}{\ln S} \quad (4)$$

Notation H'= Shannon-Wiener species diversity index and S=total species found. An evenness index value close to one indicates that the number of individuals in a community is more evenly distributed across all species found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned.
Simpson index (Dominance Index) is calculated using the equation is

$$\text{D} = \sum \left(\frac{ni}{N}\right)^2 \quad (5)$$

The dominance index ranges from 0 to 1. Where the smaller the Simpson index value indicates that no species dominates, the higher the dominance value indicates that certain species dominate [13]
The similarity of the bat community was calculated using the Jaccard index (Cj) with the equation is

$$\text{Cj} = \frac{j}{(a+b-j)} \quad (6)$$

Notation Cj = Jaccard index, a = number of species found in habitat a, b = number of species found in habitat b, and j = number of species found in both habitats. The Community Similarity Index is used to determine the similarity of bat species found in different habitats. The bat species similarity index was calculated using the Jaccard index (Cj). Analysis using Paleontological Statistical (PAST) [14].

RESULTS AND DISCUSSION

Bats Species

The number of individual bats caught in the Gunung Tunak Nature Tourism Park was 112 individuals with 6 species, namely Cynopterus Nusatenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus, and Cynopterus horsfieldii (Table 1).

TABLE 1. Types and Number of Individual Bats in Gunung Tunak Nature Tourism Park

Bat Species	Cave	Hill	Forest	Total
Cynopterus nusatenggara	15	5	6	26
Eonycteris speleae	25	19	0	44
Hipposideros diadema	0	0	5	5
Rousettus amplexicaudatus	7	5	0	12
Macroglossus minimus	10	2	0	12
Cynopterus horsfieldii	7	4	2	13
Number Species	**5**	**5**	**3**	**13**
Individuals	**64**	**35**	**13**	**112**

Based on the data in Table 1, it is stated that there were 44 individuals of *Eonycteris spelaea* caught, this number is much higher than other types of bats caught. *E. spelaea* was found at two sampling points, namely in the Bukit Cave . *E. spelaea* in the IUCN Red List is included in the Least Concern (LC) category [15], but in this study, it is stated that *E. spelaea* has a fairly high number of individuals and is found in several types of habitats, such as caves and hills. *E. spelaea* has a fairly wide distribution, ranging from Malay-Indonesian, the South China Islands, and India [16]. *E. spelaea* has also been found in plantation areas, primary and secondary forests, and mangrove forests [16]. *E. spelaea* has very important benefits in creating a balance of plant ecosystems [17]; [18]; [19]. *E. spelaea* has a function as a pollinator for several high-value plants such as durian (*Durio zibethinus*), and petai (*P. speciosa*) [20]; [21]

Hipposideros diadema is one of the suborder Microchiroptera bats found in the Gunung Tunak Nature Tourism Park. The meeting point is in the middle of the forest 500 meters from the deer breeding location. The number of arrests is only small, namely only 5 individuals. The morphology of *H. diadema* found in Gunung Tunak Nature Tourism Park was quite different from the *H. diadema* found previously. The body size is much larger, the bodyweight reaches 60-70 g and the forearm length of the wings reaches 75-90 mm. *H. diadema* is listed on the IUCN Red List as a species of Least Concern (LC). On the island of Lombok, the spread of *H. diadema* has been reported in several locations including Gale-gale Bangkang Cave, Tanjung Ringgit Cave and Buwun Cave [10], [11]. While in Indonesia, the distribution is quite wide, including in Bintuni Bay, Papua [22] and South Sulawesi in Maros Pangkep Karst [23] While outside Indonesia, *H. diadema* has been reported to exist in Perak Malaysia [24], India [25], and in caves in Bohol Island Philippines [26]

Bat Diversity

The diversity data in this study consisted of the species richness index (Margalef Index), species dominance index (Simpson Index), the diversity index (Shannon Index), and evenness index (Evenness Index).

Based on the results of the analysis, the Shannon Index states that the highest Shannon index value is at the sampling point carried out in the Cave with a value of H'= 1.481 and the lowest is at the sampling point in the forest with a value of H'= 1.012. In the Pielou Index, the highest value is at the sampling point in the forest with a value of E'= 0.917 and the lowest is at the sampling point in the hills with a value of E'= 0.733. In the Simpson Index the highest value is at the sampling point conducted in the cave with a value of D = 0.744 and the lowest is at the sampling point in the forest with a value of D = 0.615, and the last is the results of the analysis of the Margalef Index, the highest Margalef Index value is at the point Sampling was carried out in the hills with a value of R = 1.125 and the lowest was at the sampling point in the forest with a value of R = 0.780 (Figure 2).

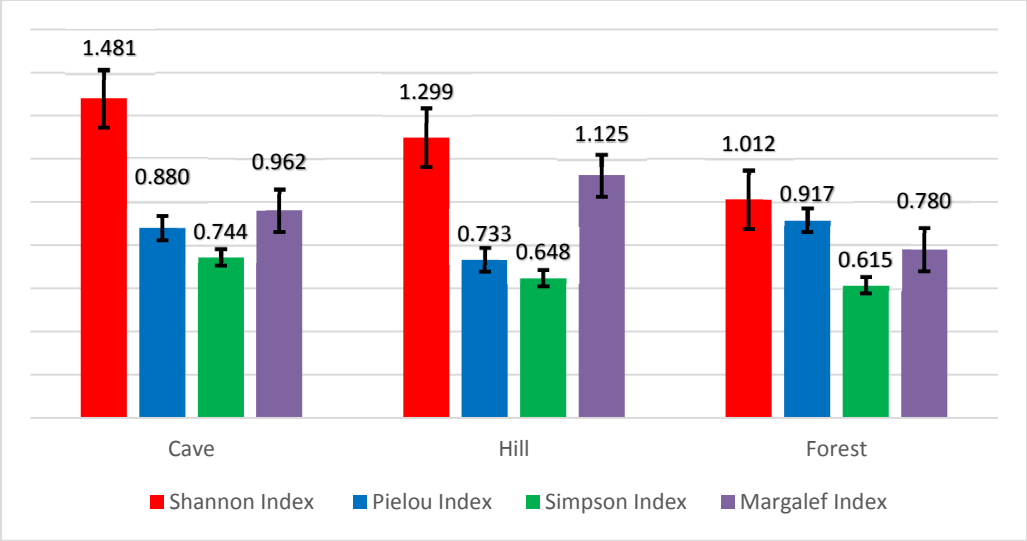

FIGURE 2. Diversity Index

Based on the research results shown in Figure 2, it is stated that the Shannon Index in the cave habitat is higher than in other habitats. This could be because the number of species richness that inhabits the cave is higher than in other habitats. In addition, the number of individuals caught is also higher. Bats are more likely to choose cave habitats than other habitats. The stable and humid conditions of the cave cause many species of bats to choose to roost in the cave. The presence of a high population of bats in the cave can benefit the bats from each other, because the cold and humid conditions of the cave will make the microclimate of the cave stable [27]. Another advantage that is obtained when bats live in large colonies is that according to [28] some of the advantages of living in colonies are the transfer of information, safety to predators, reproductive success, and thermoregulation. The highest diversity in the cave habitat is also due to the large variety of cave conditions. In the cave, many spaces allow a wide variety of species to inhabit the available space. States that each type of bat will choose a different nest or perch according to environmental conditions that suit their needs and the more variations in the condition of the cave, the more variations in the types of bats that inhabit the cave [29].

While in the Pielou Index, the evenness value that is close to number one is found in forest habitats, which is 0.917. This is because in this observation only one species different was found in the forest habitat (*H.diadema*). Evenness can change if the species found in the habitat is more than one species. The evenness index value close to the value of one indicates that the number of individuals in a community is more evenly distributed across all species found, whereas if it is close to zero it indicates an uneven distribution of the number of individuals in all species or there is the dominance of a species in the community concerned. The Simpson Index (Dominance Index) shows the index value below the number one ranging from 0 to 0.7. Thus, the dominance index in the Gunung Tunak natural park shows that there are no dominant species in that habitat.

Community Similarities

Community similarity was analyzed using the Jaccard similarity index. There are two types of analysis carried out in this study, namely the habitat use similarity index (Table 2) and the species similarity index in each habitat (Table 3). The Jaccard similarity index has a value equal to 1 if there is full equality. The results of the analysis of the community similarity index show that there is one group of habitat types that have a Jaccard similarity index value equal to 1, namely forest and hill habitats.

TABLE 2. Community Similarity Index Value

	Cave	**Hill**	**Forest**
Cave	1	1	0.333
Hill		1	0.333
Forest			1

Based on the results in Table 2, it is stated that the bat communities in caves and hills resulted in a Jaccard similarity index value equal to 1. It means that these two habitat types have full community similarities. This is because there are two species of the same bat found in both habitats. The two species are *Eonycteris speleae* and *Cynopterus nusatenggara*. However, stated that the grouping of species in a habitat does not only depend on the similarity of the species that inhabit the habitat, but the similarity of habitat environmental factors also plays a role in determining the habitat of an organism [27] The following are the results of the cluster analysis formed in Figure 3 below.

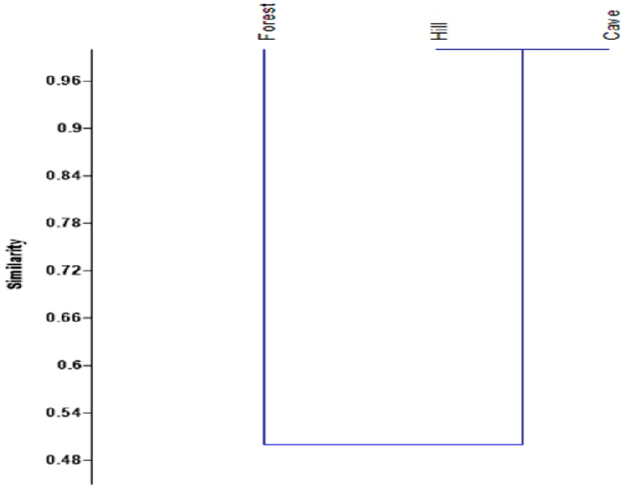

FIGURE 3. Dendogram Community similarity

Burkhalter mention that species richness and relative abundance are some of the important attributes of an ecosystem and can be a marker in a community [30]. However, Chao stated that the Jaccard community similarity index was based on the presence or absence of the same species in the habitat being compared and did not consider the abundance of species in a habitat [31].

TABLE 3. Species Similarity Index

	C.nusatenggara	*E.speleae*	*H.diadema*	*R.amplexicaudatus*	*M.minimus*	*C.horsfieldii*
C.nusatenggara	1	0.667	0.333	0.667	0.667	1
E.speleae		1	0.000	1	1	0.667
H.diadema			1	0.000	0.000	0.333
R.amplexicaudatus				1	1	0.667
M.minimus					1	0.667
C.horsfieldii						1

While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity that get scores including, group 1 (*C.nusatenggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*). There are several factors that cause full species similarity, including the first because the 4 groups formed tend to choose the same habitat. Both types of food are the same, the four groups are both fruit eaters. The following dendrogram is formed in Figure 4 below.

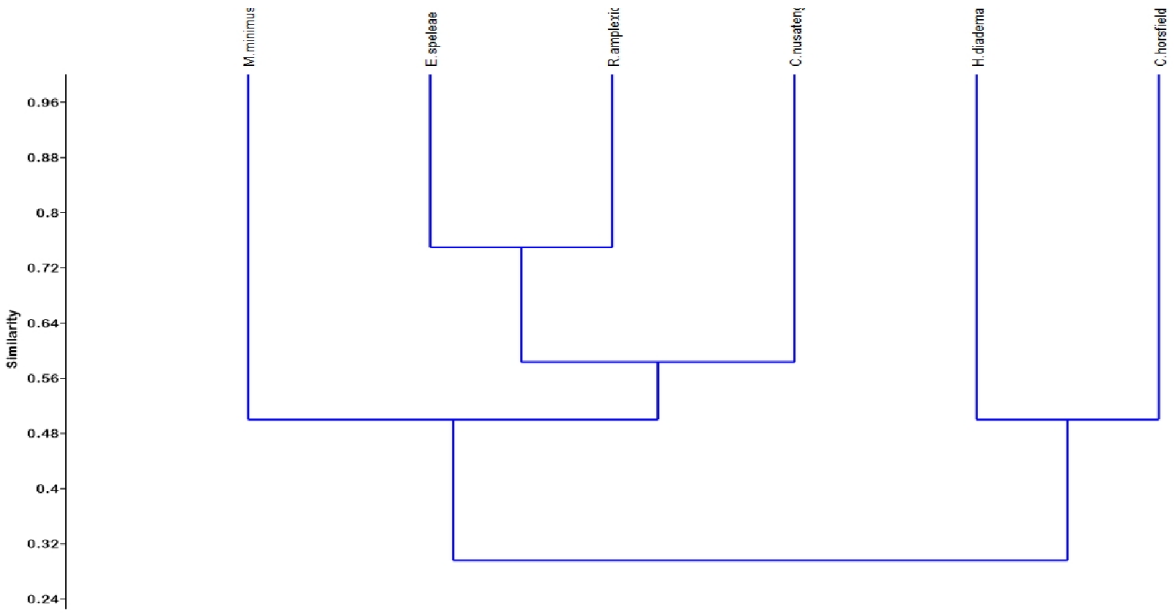

FIGURE 4. Species Similarity Dendrogram

CONCLUSION

The results showed that, based on 112 individual bats caught in Gunung Tunak Nature Tourism Park, there were 6 species (*Cynopterus Nusantenggara, Eonycteris speleae, Hipposideros diadema, Rousettus amplexicaudatus, Macroglossus minimus*, and *Cynopterus horsfieldii*). The results of the analysis of the highest margalef index were found in the Hill habitat of 1,125 and the lowest was in the forest habitat of 0.780. In the Shannon Index, the highest index value is in the Cave habitat of 1,481 and the lowest is in the forest habitat of 1,012. Furthermore, the Pielou Index analysis obtained the highest index value in the forest habitat with a value of 0.917 and the lowest in the Hil habitat of 0.733. while the highest Simpson index value is in the Cave habitat of 0.744 and the lowest is in the forest habitat of 0.615. The results of the analysis of the community similarity index using the Jaccard index stated that there were two types of habitats that showed complete similarity because they obtained a Jaccard index value of 1, namely cave and hill habitats. While the species similarity index based on the comparison of habitat types shows that, there are 4 groups that form full species similarity which gets a score of 1 of them, group 1 (*C.nusanggara* and *C.horsfieldii*), group 2 (*E.speleae* and *R.amplexicaudatus*), group 3 (*E. speleae* and *M. minimus*) and group 4 (*R. amplexicaudatus* and *M. minimus*).

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