



# Diversity of Fruit Bats (Pteropodidae) in Nature Tourism Park, Lombok Island, West Nusa Tenggara

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**Abstract.** On the Lombok Island, there are 6 Nature Tourism Park that have a diversity of flora and fauna, and beautiful natural phenomena, which can be used as tourist attractions, culture and history including; Suranadi Nature Park, Kerandangan Nature Park, Gunung Tunak Nature Park, Tanjung Tampa Nature Park, Bangko-Bangko Nature Park, and Pelangan Nature Park. Bats are one of the faunas that can be found in the Lombok Island Nature Tourism Park. Bats have a very important role in the area and the surrounding environment, namely playing a role in the process of pollination, dispersal of plant seeds and pest control so that they play a role in preserving the ecosystem of the area. On the Lombok Island, there are 39 species of bats or 20% of the types of bats in Indonesia, one of which is endemic to the Lombok Island. The study aimed to map the distribution of fruit bats (Pteropodidae) communities in Lombok Island Nature Tourism Park. The research method is carried out by survey method using the trapping technique (Mist Net and Harp Net). Mapping the distribution of bats will be based on the coordinates of the bat species found. Furthermore, mapping of bat species was carried out using PCA modelling. The results showed that of the 175 individuals caught, there were 9 species of fruit bats (Pteropodidae) that in the Lombok Island Nature Tourism Park, namely *Macroglossus minimus*, *Eonycteris spelaea*, *Cynopterus titthaecheilus*, *Cynopterus sphinx*, *Cynopterus horsfieldii*, *Cynopterus nusatenggara*, *Rousettus amplexicaudatus*, *Dobsonia peronei*, dan *Rousettus leschenaultia*. The results of the analysis of the abundance of bats in six Lombok Island Nature Tourism Park stated that the highest abundance was in the Gunung Tunak with 36.57% and the lowest abundance was in Tanjung Tampa and Suranadi with 10.86%. While the abundance of species stated that, *Eonycteris spelaea* had the highest abundance with 35.43% and the lowest abundance was *Rousettus leschenaultia* with 2.29%. Diversity analysis states that the highest dominant value is found in Tanjung Tampa with 0.48 and the lowest is in Pelang with 0.19. The highest Margalef Index value is found in Pelangan at 1.46 and the lowest is in Tanjung Tampa at 0.68. The highest Shannon Winer index value is in Pelangan at 1.72 and the lowest

is in Tanjung Tampa at 0.88. Furthermore, the highest Evenness Index value is in Kerandangan at 0.99 and the lowest is at Mount Tunak and Tanjung Tampa at 0.80. The results of the analysis of the similarity index found in each habitat were that 2 community similarity groups were formed, including group A consisting of Bangko-Bangko, Kerandangan and Suranadi, and group B consisting of Gunung Tunak, Tanjung Tampa and Pelangan. Meanwhile, mapping of bat species using PCA modelling states that there are 4 species groups formed, group A (Tosca) consisting of *Rousettus leschenaultia* and *Dobsonia peronei*, group B (Red) consisting of *Cynopterus sphinx* and *Cynopterus titthaechelilus*, group C (Purple) consisting of *Cynopterus nusatenggara*, *Eonycteris spelaea* and *Macroglossus minimus*, and group D (Yellow) consists of *Rousettus amplexicaudatus* and *Cynopterus horsfieldii*.

**Keywords:** Diversity · Fruit Bats · Nature Tourism Park · Lombok Island · West Nusa Tenggara

## 1 Introduction

Bats are one of the most abundant groups of mammals in the number of individuals. The number of species reported to date is around 1.232 species [1]. Bats are also reported to have an important role in ecology, that is bats as predators. In addition, bats are also used as seed spreader, pollination, distribution of materials and nutrients, and recycling [2, 3]. However, bats (especially fruit bats) also experience many anthropogenic threats that can affect their survival, such as hunting and habitat destruction [4, 5].

The existence of bats on Lombok Island has recently been widely reported, there are 39 species of bats with one endemic species [6, 7, 8, 9, 10]. Biogeographically, Lombok Island is one part of a series of islands that fall within the distribution boundaries of the Wallacea area. Therefore, Lombok Island can be categorized as an area that has a unique bioecological nature that allows it to be used as a biodiversity centre. In addition to the unique bioecology of Lombok Island, it is also a tourist spot that is starting to be favoured by domestic and foreign tourists. One of the tourism potentials that tourists are interested in is ecotourism. The concept of ecotourism has been developed on the island of Lombok for the last 3 years because it is believed to be profitable and environmentally friendly. The tourist attraction that is a special interest tourist attraction is the Natural Park.

Nature Tourism Park is a protected and well managed forest area. Based on the Decree of the Minister of Forestry in 1990, 6 areas have been designated as nature tourism parks, namely Suranadi Nature Park, Kerandangan Nature Park, Gunung Tunak Nature Park, Tanjung Tampa Nature Park, Bangko-Bangko Nature Park, and Pelangan Nature Park [11]. The potentials of the 6 Nature Tourism Park are different and quite abundant, one of which is bats. Several types of bats have been reported in the Nature Tourism Park area, including in Suranadi Nature Park; *Chaerephon plicata*, *Rousettus ieschenaultii*, *Macroglossus minimus*, *Hipposideros ater*, *Hipposideros diadema*, *Rhinolophus affinis*, and *Murina cyclotis*. In Pelangan Nature Park, there are *Cynopterus horsfieldi*, *Eonycteris spelaea*, *Rhinolophus acuminatus*, *Phoniscus atrox* and *Pteropus lombocensis* which are endemic bats to Lombok Island [6].

Based on the previous reference, in the Suranadi and Pelalang nature tourism parks, more bats from the Suborder Pteripodidae were found than bats from other suborders. This is because bats from the suborder Pteripodidae are more likely to choose forest habitats than other habitats. After all, there is no direct competition from similar species and other herbivorous species in their survival [12].

The previous information on the existence of bats is of course an additional reference in conducting an observational study again in a natural tourism park on the Lombok Island with the hope that this research can be a reference for area managers and area visitors. Thus the study aims to conduct a thorough monitoring of the six natural tourism parks on the island of Lombok and to examine the abundance, diversity, community similarity and mapping of fruit bat species (Pteropodidae) in the nature tourism parks of Lombok Island.

## 2 Research Method

### 2.1 Study Area

The research was carried out in nature tourism parks on the Lombok Island including: Bangko-Bangko ( $08^{\circ} 43' 20''$ -  $08^{\circ} 47' 23''$  South Latitude and  $115^{\circ} 49' 20''$ -  $115^{\circ} 52' 10''$  East Longitude), Pangangan ( $08^{\circ} 45' 38''$  -  $8^{\circ} 51' 04''$  South Latitude and  $115^{\circ} 57' 0''$ -  $115^{\circ} 58' 38''$ E), Kerandangan ( $08^{\circ} 20' 13''$  -  $08^{\circ} 20' 15''$  South Latitude and  $116^{\circ} 04' 00''$  –  $116^{\circ} 04' 03''$  east longitude), Suranadi ( $08^{\circ} 34' 13''$  -  $08^{\circ} 34' 15''$  south latitude, and  $116^{\circ} 13' 00''$  –  $116^{\circ} 13' 02''$  east longitude), Gunung Tunak ( $08^{\circ} 53' 30''$ -  $08^{\circ} 57' 30''$  South Latitude and  $116^{\circ} 22' 00''$  -  $116^{\circ} 24' 00''$  East Longitude), and Tanjung Tampa. The six nature tourism parks share a fairly high habitat type, namely forests that are very close to the shoreline with a topography that varies from flat, slightly flat, sloping, wavy, hilly, and cliffs, except for the Suranadi nature park. The condition of the Suranadi nature park has a landscape with a flat topography and a dense cover of vegetation with a fairly high diversity of plant species that always looks green throughout the year. In addition, Suranadi Nature Park is a water catchment area and a regulator of water management for the surrounding area.

### 2.2 Bat Sample Collection

Before sampling the bats, the team observed and mapped the bat sampling locations based on their perching and foraging habits. Next, make a transect line and install a fog net at that location. For nature tourism parks that have natural habitats for bats such as caves, the installation of transect nets is carried out at the mouth of the cave. The following details the sampling locations in each natural tourism park on the island of Lombok in Table 1.

### 2.3 Identification of Samples

Bats caught in nets are then released and identified. The samples were checked manually by checking the morphological characteristics. Identification of bat samples refers to book reference [7, 6, 10].

**Table 1.** Bats Sampling Points

Location	Cave	Forest	River	Under the bridge
Gunung Tunak	✓	✓	-	-
Tanjung Tampa	✓	✓	-	-
Pelangan	✓	✓	-	-
Bangko-bangko	✓	✓	-	-
Suranadi	-	✓	✓	✓
Kerandangan	-	✓	✓	✓

## 2.4 Research Data Analysis

The captured and identified bat samples were then analyzed for species richness index (Margalef Index), Dominance, Shannon Winner Index and Evenness Index. The mapping of the distribution of bats will be based on the coordinates of the bat species found. Furthermore, mapping of bat species was carried out using PCA modelling. All data analysis processes were carried out using Paleontological Statistical (PAST) software 4.03.

## 3 Results and Discussion

### 3.1 Diversity of Bat Species in TWA Lombok Island

The number of individual fruit bats (Pteropodidae) caught in six locations of nature tourism parks (Gunung Tunak, Tanjung Tampa, Pelangan, Bangko-Bangko, Suranadi and Kerandangan) was 175 individuals with 9 species (*Macroglossus minimus*, *Eonycteris spelaea*, *Cynopterus titthaecheilus*, *Cynopterus sphinx*, *Cynopterus horsfieldii*, *Cynopterus nusatenggara*, *Rousettus amplexicaudatus*, *Dobsonia peronei*, dan *Rousettus leschenaultia*) (Table 1).

Information M = Male dan F = Female.

Based on the analysis of the abundance of bats in 6 (six) Lombok Island Nature Parks (Table 2), it is stated that the highest abundance is in Gunung Tunak with 36.57% and the lowest abundance is in Tanjung Tampa and Suranadi with 10.86%. While the abundance of species stated that, *Eonycteris spelaea* had the highest abundance with 35.43% and the lowest abundance was *Rousettus leschenaultia* with 2.29%.

Gunung Tunak Nature Tourism Park has a total area of 936.02 hectares. In 2010 a boundary demarcation activity was carried out at Mount Tunak based on the Decree of the Minister of Forestry No. 598/Menhut-II/2009 dated October 2, 2009, with the result of demarcation of an area of  $\pm 1,219.97$  hectares. Gunung Tunak Nature Tourism Park is the only conservation area in Central Lombok Regency which is used for the benefit and development of tourism and nature recreation [11]. The topography of Gunung Tunak with a lowland ecosystem type causes various types of fauna to be abundant, one of which is bats. A sampling of bats at GunungTunak was carried out in several places,

**Table 2.** Fruit Bats (Pteropodidae).

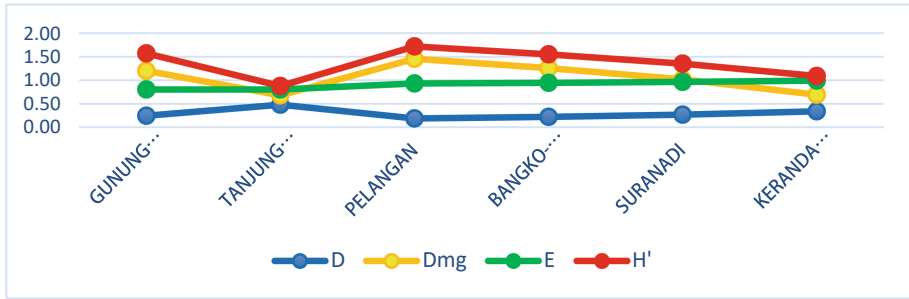
No	Species	GUNUNG TUNAK		TANJUNG TAMPA		PELANGAN		BANGKO BANGKO		SURANADI		KERANDANGAN		TOTAL	%
		M	F	M	F	M	F	M	F	M	F	M	F		
1	<i>Macroglossus minimus</i>	7	3	3	2	1	4	-	-	4	-	-	-	24	13.71
2	<i>Eonycteris spelaea</i>	15	10	10	2	6		3	2	5	2	6	1	62	35.43
3	<i>Cynopterus titthaechelilus</i>	-	-	-	-	-	4	1	2	-	-	-	-	7	4.00
4	<i>Cynopterus sphinx</i>	2	-	-	-	-	-	5	2	4	-	-	-	13	7.43
5	<i>Cynopterus horsfieldii</i>	5	2	-	-	7	1	-	-	-	-	-	-	15	8.57
6	<i>Cynopterus nusatenggara</i>	8	5	2				5	1			4	1	26	14.86
7	<i>Rousettus amplexicadatus</i>	5	2	-	-	6	-	-	-	-	-	2	4	19	10.86
8	<i>Dobsonia peronei</i>	-	-	-	-	2	-	2	1	-	-	-	-	5	2.86
9	<i>Rousettus leschenaultia</i>	-	-	-	-	-	-	-	-	3	1	-	-	4	2.29
	TOTAL	42	22	15	4	22	9	16	8	16	3	12	6	175	
	TOTAL	64		19		31		24		19		18		175	
	%	36.57		10.86		17.71		13.71		10.86		10.29			

including the Teluk Ujung cave and several points in the forest. However, most individual bats were found in the cave. Teluk Ujung Cave is a cave located on the beach which has a large enough space that can accommodate hundreds to thousands of bats in it. Caves are one of the natural habitats of bats. In the cave, bats can avoid predators, bad weather, places for social interaction and as a provider of food (Guano) in significant quantities for other organisms in the cave [4, 13]. In addition, the presence of bats can change the microclimate of the cave, so that bats become energy providers for other ecosystems. Caves are so important to bats worldwide that most species, including many vulnerable and rare, are either specialized cave dwellers or use temporary caves [14].

Tanjung Tampa nature tourism park has a similarity in sampling with Gunung Tunak, namely bat samples were also obtained from caves, but the condition of the cave in Tanjung Tampa is different. The cave space is narrow and covered by seawater when the tide is in, causing the presence of bats to not be abundant. This also causes the percentage of bat abundance in Tanjung Tampa to be lower than in other locations.

Based on the analysis of the percentage abundance of bat species in the nature tourism park on the Lombok Island, it was stated that the *Eonycteris spelaea* bat species had the highest abundance with 35.43%. Based on IUCN Red List records, *Eonycteris spelaea* was reported with Least Concern (LC) status [15], but its presence on Lombok Island is very high. *E. spelaea* has been reported to exist in Tanjung Ringgit Cave, Bangkang Gale-gale Cave, and Buwun Cave [16].

*E. spelaea* has a fairly wide distribution, ranging from Malay-Indonesian, South China islands, and India [17]. The habitat of *E. spelaea* has been reported to be found in several places, such as plantation areas, primary and secondary forests and mangrove



**Fig. 1.** Bats Diversity

forests [18, 19]. *E. spelaea* has very important benefits in creating a balance of plant ecosystems [20, 21, 22] and *E. spelaea* has a function as a pollinator for several high-value plants such as durian (*Durio zibethinus*), and petai (*P. speciosa*) [12, 20, 23].

### 3.2 Bats Diversity

Diversity analysis (Fig. 1) states that the highest dominant value is found in Tanjung Tampa at 0.48 and the lowest is in Pelangan at 0.19. The highest Margalef Index value was found in Pelangan at 1.46 and the lowest in Tanjung Tampa at 0.68. The highest Shannon Winer index value is in Pelangan at 1.72 and the lowest is in Tanjung Tampa at 0.88. Furthermore, the highest Evenness Index value is in Kerandangan at 0.99 and the lowest is at Gunung Tunak and Tanjung Tampa at 0.80.

The high value of the diversity index can be caused by several factors, including the high number of bat species and the number of individual bats that inhabit a habitat. Another factor is suitable, stable habitat conditions and the availability of abundant feed. In bats living in caves, the high diversity of bat species can be caused by the formation of a microclimate in the cave, thus causing a separation of the microclimate in the cave which can trigger the diversity of bat species in it [24]. 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. Thus, it can be concluded that the condition of the cave that has a complete zone can result in an abundance of bat species that inhabit the cave [25]. Meanwhile, in the Evenness Index, the highest Evenness Index value is found in Kerandangan at 0.99 and the lowest is at Gunung Tunak and Tanjung Tampa at 0.80. Kerandangan nature tourism park obtained an index value close to 1. Magurran said that an evenness value close to one indicates that a community is more evenly distributed, whereas if the value is close to zero, the distribution is more uneven. Thus, it can be concluded that the bat community in the Kerandangan nature park has an even distribution [26].

### 3.3 Community Mapping

Community similarities were carried out to get an overview of the bat communities located in six Nature Tourism Parks on the Lombok Island. This similarity analysis

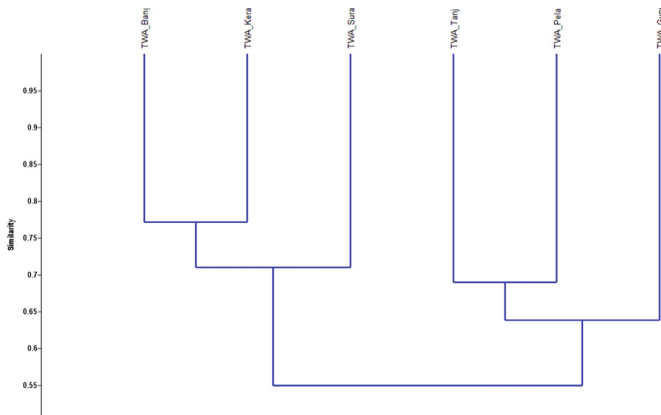
uses the estimation of the Binary Coefficients community parameters, namely using the Jaccard Similarity Indices (JI) (Table 3). The data used is the data on the species and the number of individual bats in each Nature Park.

The results of the analysis of the similarity index found in each habitat were then carried out with cluster analysis (grouping). The analysis of the community similarity test was carried out using Cluster Analysis. Following are the results of the cluster analysis in the dendrogram image (Fig. 2).

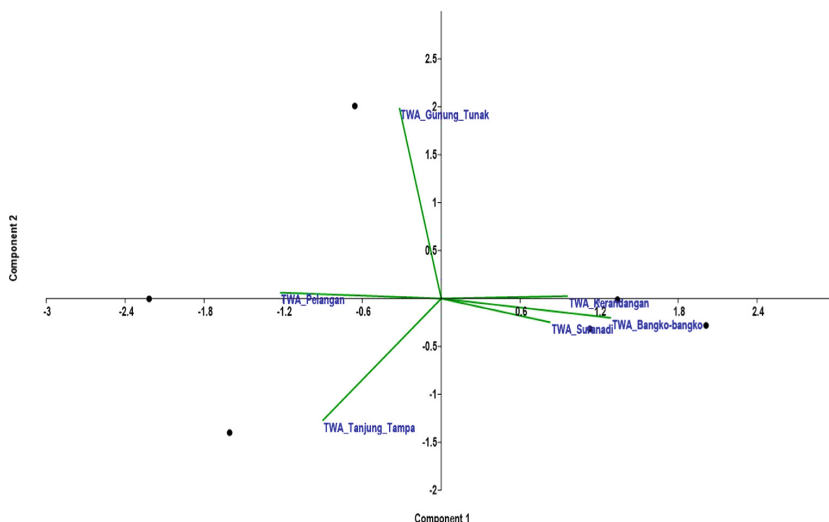
Based on Fig. 2, it is stated that, 2 community similarity groupings were formed, including group A consisting of Bangko-bangko, Kerandangan and Suranadi, group B consisting of Gunung Tunak, Tanjung Tampa and Pelangan. The formation of communities A and B can be caused because the habitat has 4 species that inhabit the same habitat and have a fairly high abundance of individuals. Burkhalter stated that species richness and relative abundance are one of the important attributes of an ecosystem and can be a marker in a community [27]. However, Chao *et al.* stated that the Jaccard community similarity index was based on the presence or absence of the same species in the habitat

**Table 3.** Similarity Indices Jaccard (JI)

Location	Gunung Tunak	Tanjung Tampa	Pelangan	Bangko bangko	Suranadi	Kerandangan
Gunung Tunak	1	0.273	0.385	0.273	0.308	0.364
Tanjung Tampa		1	0.455	0.200	0.250	0.300
Pelangan			1	0.067	0.188	0.214
Bangko-bangko				1	0.500	0.625
Suranadi					1	0.333
Kerandangan						1



**Fig. 2.** Dendrogram community similarity



**Fig. 3.** Community Similarity Mapping with PCA

being compared and did not consider the abundance of species in a habitat [28]. Further testing of community similarity using PCA (Principal Component Analysis) aims to determine the similarity of species that inhabit each community. The following is a linear combination that is formed to produce a new variable in Fig. 3.

Based on Fig. 3 it also states that there are two groups formed. The first group (TWA Gunung Tunak, TWA Tanjung Tampa and TWA Pelangan) formed a community structure that was negatively correlated with the number of species and individual bats in each habitat with both obtaining negative R values, namely -0.656, -1.608 and -2.218. While the second group (TWA Suranadi, TWA Kerandangan and TWA Bangko-bangko) formed a community structure that was positively correlated with the number of species and individual bats in each habitat by both obtaining positive R values, namely 2,013, 1,130, and 1,340.

### 3.4 Species Mapping

Species mapping was carried out using data on the number of species, and mapping of bat species was carried out using PCA modelling. The results of mapping bat species using PCA modelling state that there are 4 species groups formed, group A (Tosca) consisting of *Rousettus leschenaultia* and *Dobsonia peronei*, group B (Red) consisting of *Cynopterus sphinx* and *Cynopterus titthaechailus*, group C (Purple) consisting of from *Cynopterus nusagara*, *Eonycteris spelaea* and *Macroglossus minimus*, and group D (Yellow) consisting of *Rousettus amplexicaudatus* and *Cynopterus horsfieldii* (Fig. 4).



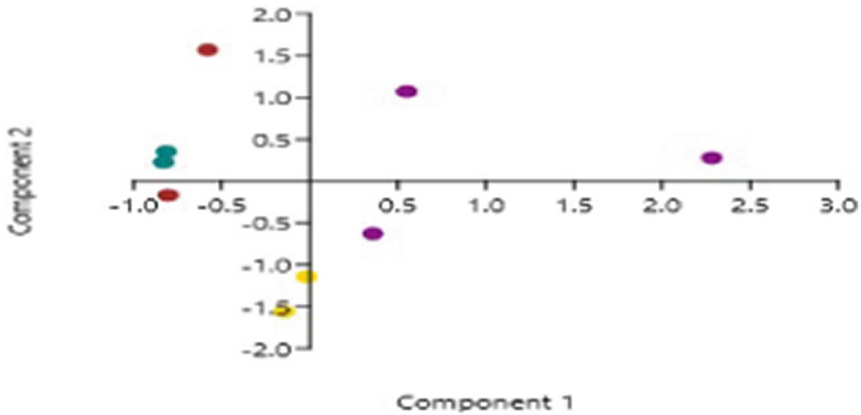


Fig. 4. Mapping Bat Species Using PCA

## 4 Conclusion

The nature tourism park on the Lombok Island is conducted that 9 species of fruit bats (Pteropodidae). Based on the analysis of the abundance of bats, it was stated that the highest abundance was in Gunung Tunak with 36.57% and the lowest abundance was in Tanjung Tampa and Suranadi with 10.86%. While the abundance of species stated that, *Eonycteris spelaea* had the highest abundance with 35.43% and the lowest abundance was *Rousettus leschenaultia* with 2.29%. In the diversity analysis, it is stated that the highest dominant value is in Tanjung Tampa at 0.48 and the lowest is in Pelangan at 0.19. The highest Margalef Index value is found in Pelangan at 1.46 and the lowest is in Tanjung Tampa at 0.68. The highest Shannon Winer index value is in Pelangan at 1.72 and the lowest is in Tanjung Tampa at 0.88. Furthermore, the highest Evenness Index value is in Kerandangan at 0.99 and the lowest is at GunungTunak and Tanjung Tampa at 0.80. The results of the analysis of the similarity index found in each habitat were that 2 community similarity groups were formed, including group A consisting of Bangko-Bangko, Kerandangan and Suranadi, and group B consisting of Gunung Tunak, Tanjung Tampa and Pelangan. Meanwhile, mapping of bat species using PCA modelling states that there are 4 species groups formed, group A (Tosca) consisting of *Rousettus leschenaultia* and *Dobsonia peronei*, group B (Red) consisting of *Cynopterus sphinx* and *Cynopterus titthaechilus*, group C (Purple) consisting of *Cynopterus nusateng-gara*, *Eonycteris spelaea* and *Macroglossus minimus*, and group D (Yellow) consisted of *Rousettus amplexicaudatus* and *Cynopterus horsfieldii*.

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