THE FRUIT BATS (MEGACHIROPTERA, PTEROPODIDAE) FROM BAWAKARAENG MOUNTAIN, SOUTH SULAWESI

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ABSTRACT. *A study of fruit bats (Pteropodidae) was conducted in the mountain region of Bawakaraeng, Gowa and Sinjai, South Sulawesi from September to December 2013. This study aims to determine the fruit bats composition and diversity, habitat preferences and relation between bats individual captured with the moon phases. Ten species (265 individuals) of fruit bats were captured using standardized mist netting in five habitat types and elevations. Shannon-Wiener indices were highest in mixed garden (1453 m asl) and lowest in pine forest (1545 m asl), with the highest evenness in mixed garden and pine forest. Principal Component Analysis (PCA) shows that the habitat preferences were found in the mixed garden (1453 m asl) and primary forest with a river stream (2000 m asl), while at moon phases, number of individual bats captured in the dark moon phase was higher than full moon phases. This study shows that the abundance of fruit bats tightly associated with food availibility.*

KEYWORDS. Fruit bats, distribution, habitat preferences, moon phases

INTRODUCTION

Bats belong to the order Chiroptera and can be distinguished from all other mammals by their ability to fly (Mickleburgh et al., 1992). Bats divided into two suborder, they are Megachiroptera (fruit-eating bats) and Microchiroptera (insect-eating bats) (Corbet and Hill, 1992; Suyanto, 2001). Fruit bats consist of a single family, Pteropodidae, which includes 44 genera and 166 species widely distributed in tropical areas (Mickleburgh et al., 1992), with 42 genera and 163 species in Indomalayan region (Corbet and Hill, 1992). In Indonesia, there are 25 genera and 76 species of fruit bats and some of them are endemic in certain areas (Corbet and Hill, 1992). Sulawesi has 28 species of fruit bats which are widespread in various areas and some of them are endemics, which are; *Boneia bidens, Cynopterus* *luzoniensis, Dobsonia exoleta, Harpyionycteris celebensis Neopteryx frosti, Pteropus pumilus, Rousettus linduensis, Styloctenium wallacei* and *Thoopterus suhaniahae* (Suyanto *et al.*, 2002).

Fruit bats have an important role in ecosystem as seed dispersers and pollinators (Mickleburgh et al., 1992). The distribution and diversity of bats are influenced by food resources, habitat types, microclimate, elevation that affect capture and bat activity (Barlow, 1999; Maryanto et al., 2011). The mountain region of Bawakaraeng, Gowa (2830 m asl), South Sulawesi is suspected to have high distribution of fruit bats (Sumaryono and Yunara, 2011). The forest type are lowland forest, secondary and primary forest with water resources (Hasnawir and Kubota, 2006). This study aims to determine the fruit bats composition, including age catagorized and reproduction status of female fruit bats, fruit bats diversity in each habitat types, habitat preferences and relation between captured individual fruit bats with the moon phases in the mountain region of Bawakaraeng.

MATERIALS AND METHODS

Study Sites

This study was conducted at Bawakaraeng mountain, Gowa and Sinjai Barat, South Sulawesi from September to December 2013. Five sites were set up at different elevations and habitats: secondary forest with a river stream (1200 m asl), mixed garden (1453 m asl), pine forest (1545 m asl), primary forest with a river stream (2000 m asl) and cave (2200 m asl) (Figure 1).

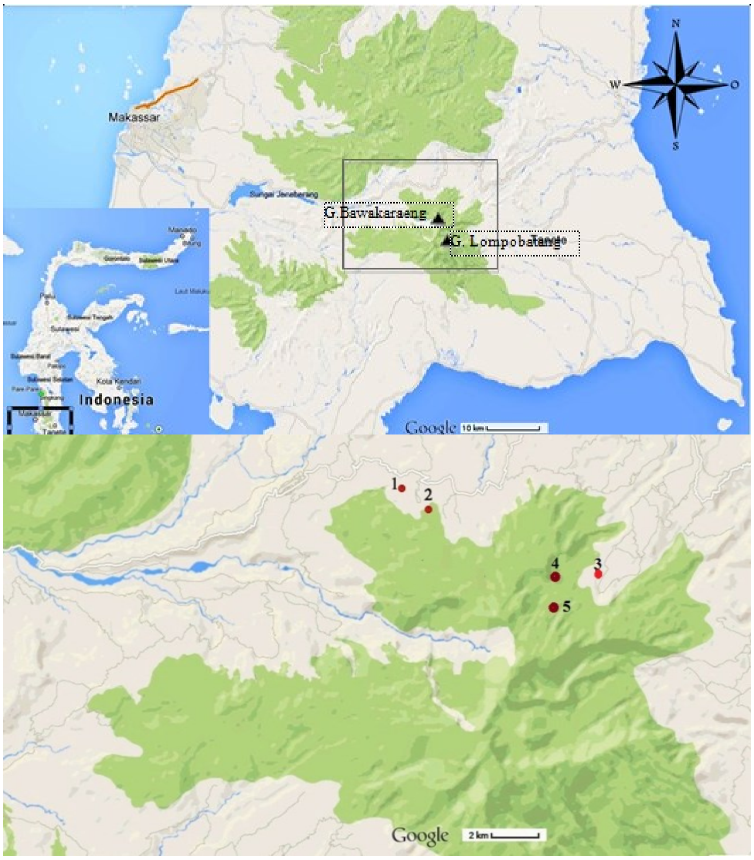

Figure 1: Collecting specimens sites (1) Mixed garden (1453 m asl); (2) Pine forest (1545 m asl) (3) Secondary forest with river streams (1200 m asl); (4) Primary forest with river streams (2000 m asl) and (5) Cave (2200 m asl) (Google Map 2014).

Bats Sampling

Mist nets were used to trap bats placed in 2-3 meter above ground. Trapped bats handled manually. Specimens were preserved in 10 % formalin for further identification.

Sample Identifications

Samples identification were based on Corbet and Hill (1992), Suyanto *et al.,* (2001) and observed against voucher bats specimen in Indonesian Institute of Science (LIPI). Identification were done until species level. Age and sex catagories were determined according to Suyanto (2001); Racey, (1988): Cristian and Helversen (2005).

Data Analysis

Estimation on species was analyzed by Estimates S 8 in order to determine the differences between number of collected and expected species (Gotelli and Colwell, 2011). Shannon-Wiener indices and Evenness (Maguran 2004) were used to compare the diversity of bats in each habitat types. Principle Component Analysis (PCA) was employed to group bats according to habitat preferences and correlation between numbers of bats individual and moon phases was analyzed using the Paleontological Statistic (PAST).

RESULTS AND DISSCUSION

Species Captured

Total number of species exist in Bawakaraeng Mountain was estimated based on the number of individuals captured each nights**.** Estimated curve were discuss differences between species number of collected and expected species (Figure 3). Sobs (Mao Tau) is the total number of species that was captured in this study. Jack 1 mean value is the first order Jacknife richness estimator of species number (Gotelli and Colwell 2011). Species estimation number during 27 nights were 12 species, it is only two species were not caught yet. Sampling effort on this study were almost maximal, the total sampling effort (5112 m^2) were representing 10 species of fruit bats (Table 1).

Table 1: Individual number of bats effort mist net/nights captured in different habitat types

Habitat	Altitude (m asl)	Bb*	Ts*	Tn	Rc*	Ra	Es	Sw*	De*	Dv	Cl*
SF	1200	0.00	3.25	0.00	15.9	0.00	0.00	0.00	0.00	0.00	0.00
MG	1453	2.35	10.29	2.35	55.6	1.76	2.65	0.59	0.59	1.76	0.29
PiF	1545	0.00	11.10	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PF	2000	55.60	4.40	2.2	4.4	0.00	0.00	0.00	0.00	0.00	0.00

Notes :
MG=Mixed Garden, PiF=Pine Forest, SF=Secondary Forest, PF=Primary Forest; Bb=*Boneia bidens*, Ts=*Thoopterus suhaeniahae*, Tn=*Thoopterus nigrescens*, Rc=*Rousettus celebensis*, Ra=*Rousettus amplexicaudatus*, Es=*Eonycteris spelaea*, Sw=*Styloctenium wallacei*, De= *Dobsonia exoleta*, Dv=*Dobsonia viridis*, Cl=*Cynopterus luzoniensis* (*= endemic species in Sulawesi and adjacent island).

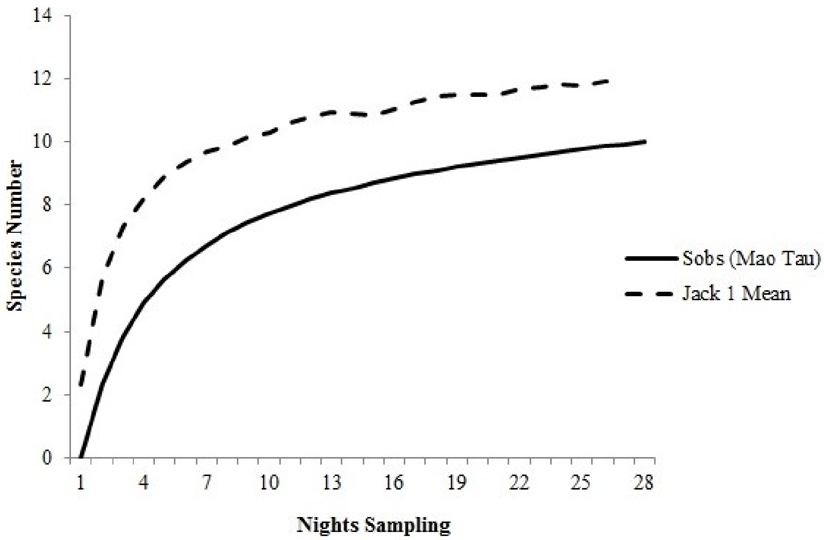

Figure 2: Estimation curve number of bats individuals, Sobs (Mao Tau) is sample observed, Jack 1 Mean is species estimation number

Factor influenced the captured success included sampling duration, mist net efficiency, the placement and regular check and environmental conditions, such as heavy rain, wind and the moon phases (Barlow, 1999; Lang et al., 2004; Larsen et al., 2007). In this study, it might possible to captured all the 12 species of fruit bats if period was to be extendeed, while there was no bats caught in heavy rain and wind. In addition, in the full moon phases there were only a few individuals of bats captured.

A total of 265 individuals of fruit bats were captured in different habitat types during 40 nights (Table 1), with 13 infants (4.90%), 16 juveniles (6.03%), 17 sub adults (6.41%) and 219 adults (82.64%). The composition of the fruit bats captured by sex was 121 females (45.66%) and 144 males (54.33%). Species composition included *Boneia bidens* (Jentink, 1989) (159 individuals; 60%), *Thoopterus suhaeniahae* Maryanto, *et al*. 2012 (50 individuals, 18.86 %), *Rousettus celebensis* K. Andersen, 1907 (21 individuals; 7.95%), *Thoopterus nigrescens* (Gray,1870) (11 individuals; 4.16%), *Eonycteris spelaea* Jentink, 1888 (9 individuals; 3.40%), *Rousettus amplexicaudatus* (Geoffroy, 1810) (6 individuals; 2.27%), *Dobsonia viridis* (Heude, 1896) (6 individuals; 2.27%), *Styloctenium wallacei* Gray, 1866 (2 individuals, 0.75%), *Dobsonia exoleta* (2 individuals; 0.75%) and *Cynopterus luzonensis* (Peters, 1861) (1 individuals; 0.37%). Five of ten fruit bats species are endemic to Sulawesi which are *Boneia bidens*, *Thoopterus suhaniahae, Styloctenium wallacei*, *Cynopterus luzoniensis* and *Dobsonia exoleta.* The fruit bats that were found in Bawakaraeng Mountain were also widely distributed in Sulawesi and adjacent island (endemic species). These species included *B. bidens, C. luzonensis, D. exoleta, S. wallacei*, *T. suhaniahae* and *T. nigrescens* (Suyanto et al., 2002), Two species which are *D. viridis* and *R. celebensi*s were endemic to Sulawesi and Molluccas. Meanwhile, *R. amplexicaudatus* and *E. spelaea* are found widely distributed throughout Indonesia (Corbet and Hill, 1992; Suyanto *et al.,* 2002).

Diversity of Fruit Bats

Shannon-Wiener diversity showed the highest value in mixed garden (1453 m asl) was 1.80 while the lowest value in pine forest (1545 m asl) was 0.32, while evenness indices value was 0.77 in mixed garden and the lowest value was 0.18 in pine forest (Table 2). The similar resulted were reported by Medellin *et al.* (2000) and Hall *et al.* (2004), where the highest individuals number of bats captured were found in agricultural areas. Another study were also found the highest abundance of fruit bats in secondary and primary forest (Heideman and Heaney 1989; Wiantoro and Ahmadi 2011).

Table 2: Total individuals number in each habitat types and variation in both Shannon-Wiener and Simpson indexes

	Number of Individuals			
	MG 1453 m asl	PiF 1545 m asl	SF 1200 m asl	PF 2000 m asl
Number of Individuals	82	10	12	60
Number of Species	10	2	2	4
Shannon-Wiener Index (H')	1.80	0.33	0.45	0.53
Simpson Index (S)	0.77	0.18	0.28	0.24

Habitat Preferences

Result of principal component analysis revealed that PC1, PC2, and PC3 for 97.92% in total variants, accounted for 52.23% (PC1), 24.08% (PC2) and 21.61% (PC3) (Figure 4). Principal component analysis showed the correlation among species and habitat types. *T. suhaniahae* was correlated with degraded habitats, such as the mixed garden (1453 m asl) and pine forest (1545 m asl), while *T. nigrescens* was correlated with pine forest. Both species were correlated with mixed garden and pine forest. *B. bidens* correlated with primary forest with river stream at 2000 m asl, while *R. celebensis* correlated with secondary forest at 1200 m asl (Figure 4). The sympatric species were found in mixed garden, which are *C. luzonensis, D. viridis*, *D. exoleta*, *E. spelaea, R. amplexicaudatus* and *S. wallacei* while four other species which are *B. bidens, R. celebensis, T. nigrescens* and *T. suhaeniahae* were found simpatrically in primary forest (2000 m asl).

Cynopterus generally found in garden and roosting in leaf of trees with high light intensity (Storz, 2000). *B. bidens, R. celebensis, T. suhaniahae,* and *T. nigrescens* are generally found in forests with a shelter rock as roosting habitat, but occupied in agroforestry as foraging habitats (Bergmans and Rozendall, 1988; Maryanto and Yani, 2003; Maryanto *et al.,* 2011; Maryanto *et al.,* 2012). *B. bidens* are generally found in upper mountain areas at 1800-2000 m asl and caves (Bergmans and Rozendaal, 1988; Maryanto *et al.*, 2011). *T. suhaniahae*, *T. nigrescens* and *R. celebensis* were generally found in mixed garden such as cacao and coffee, secondary and primary forests and lower forest areas (Maryanto *et al.,* 2012). Species that are specialized nectarivorus, such as *E. spelaea* and *R. amplexicaudatus* were commonly found in agricultural areas with flowers availability. Both species play a major in pollination and seed dispersers (Heideman and Heaney 1989; Maryanto *et al.,* 2011), while *D. exoleta*, *D. viridis* and *S. wallacei* were generally found near guava trees (Esselsstyn, 2007).

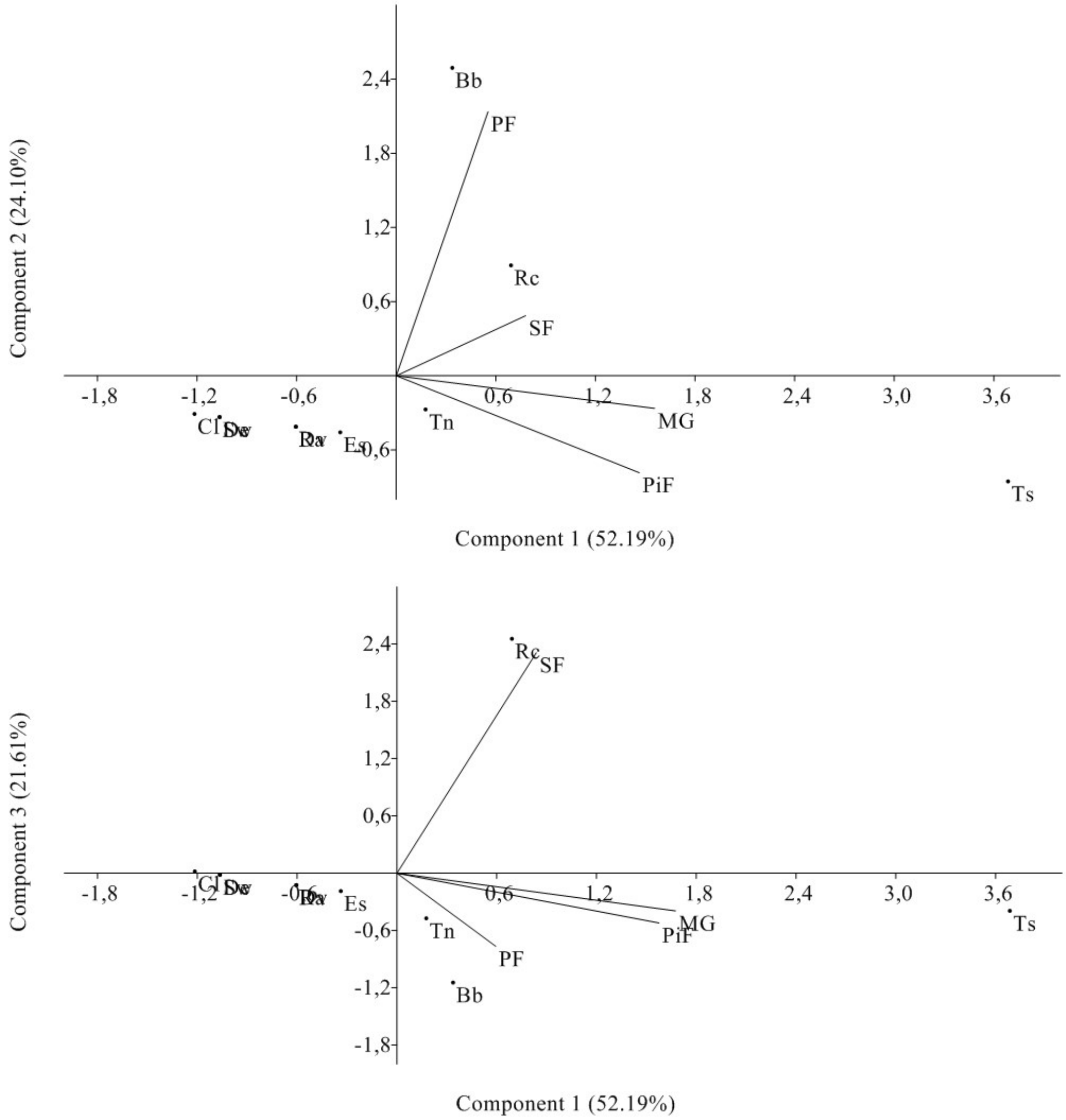

Figure 4: Principal component analysis (PC1, PC2, and PC3) accounted for 97.92% explained the correlation between fruit bats and habitat

Fruit Bat Individuals Number Captured In Relation To Moon Phases

Species that were captured each night was calculated by sampling effort to standardised individuals number of bats (Table 2). Principal component analyses revealed that PC1, PC2, and PC3 for 96.06% in total variants, accounted for 53.02% (PC1), 37.16% (PC2) and 5.88% (PC3). The three moon phases which are new moon, waxing gibbous and full moon correlated with *B. bidens* and *R. celebensis*. Two species that were related to crescent and first quarter phases, are *T. suhaniahae, D. exoleta* and *D. viridis*, whereas species that were related with waxing gibbous phases was *R. celebensis* (Figure 5).

All species mostly found in new moon, crescent, first quarter and waxing gibbous, except for *B. bidens* that was found in full moon phases. Lunar phobia has been reported in several bat species in the Neotropics and suggested to occur due to predation risk (Lang et al., 2005; Bork, 2006; Mello et al., 2013). Lang et al., (2005) reported that foraging activity of *Lophostoma silvicolum* was higher in new moon phases than full moon phases. Some studies reported that the number individuals captured of *Noctilio leporinus* (Bork, 2006); *Artibeus lituratus*, *Carollia perspicillata*, *Sturnira lilium* (Mello *et al.,* 2013) were higher in dark moon phases, new moon, waning gibbous and waxing gibbous than during full moon phases. Bats that were found in full moon phases are probably adapted to light intensity than other bats. *B. bidens* that were found in full moon phases showed that this species was more adapted to the moonlight intensity, suspected this species were found in degraded habitat, such as agricultural (Bergmans and Rozendaal, 1988).

Table 3: Effort of individuals captured mist net/nights based on moon phases

Moon Phases	Individuals number of bats captured									
	Ts	Tn	Bb	Rc	Ra	Es	De	Dv	Sw	Cl
A	25.7	14	104.74	15.99	12.35	6.17	6.17	0.00	0.00	0.00
B	48.48	3.97	8.37	5.95	3.97	8.37	1.98	3.97	2.42	0.00
C	20.70	9.00	2.06	5.85	2.06	1.74	0.00	12.8	1.74	2.06
D	27.78	0	43.65	39.68	3.97	0.00	0.00	0.00	0.00	0.00
E	0.00	0.00	22.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(Abbreviations of moon phases A=new moon, B=crescent, C=first quarter, D=waxing gibbous, E=full moon. Abbreviation of species name refer to table 1)

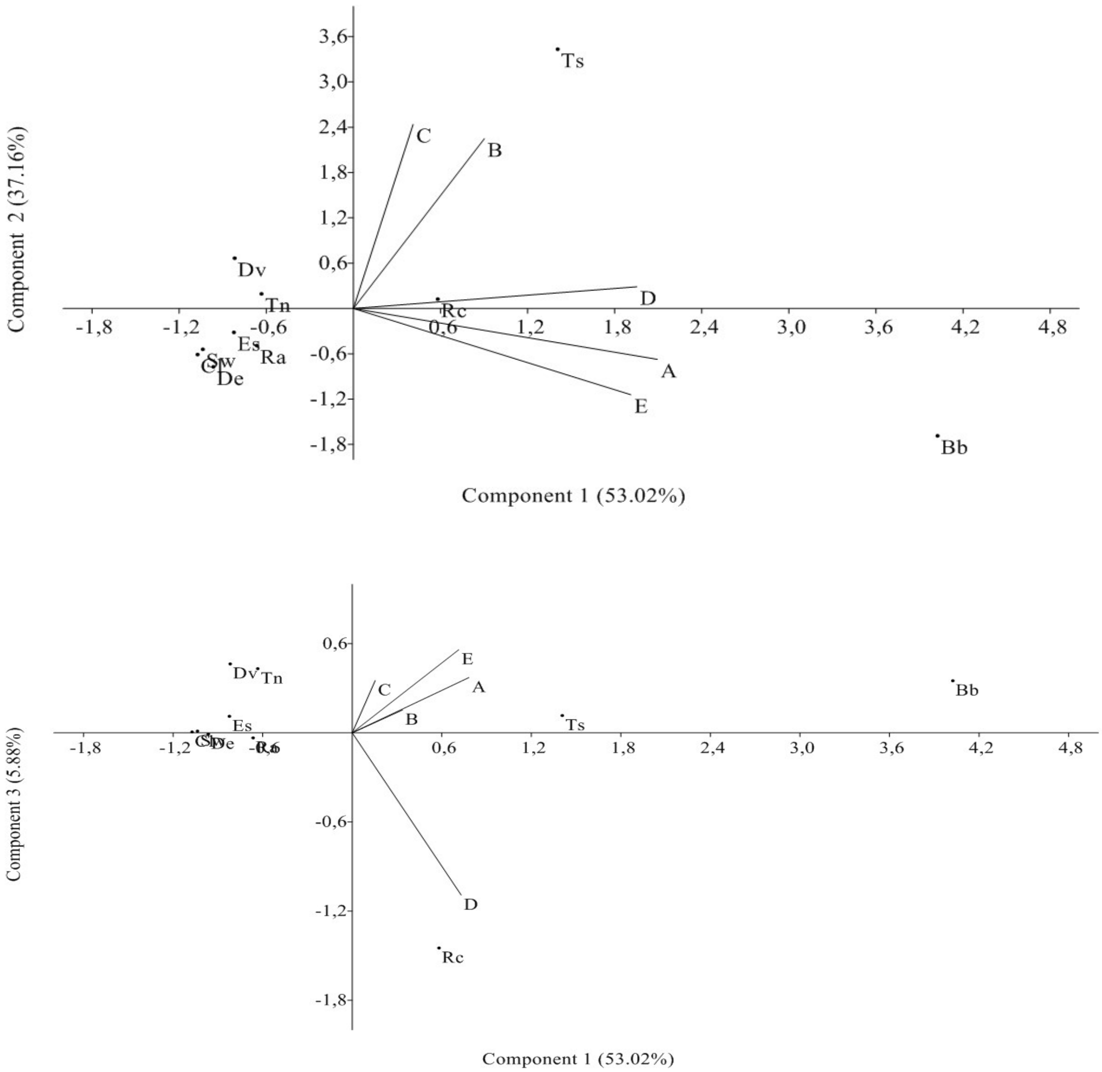

Figure 5: Principal component analysis of individuals bat number in relation to moon phases, A=new moon, B=Crescent, C=first quarter, D=waxing gibbous, E=full moon.

CONCLUSIONS

Fruit bats that were captured in different habitat types in Bawakaraeng mountain play major in pollination and seed dispersal, they are *Rousettus amplexicaudatus* and *Eonycteris spleae* that is important in ecosystem. Diversity of fruit bats were tightly associated with habitat types in relation to food availability. The highest individual fruit bats captured in Bawakaraeng mountain were *Boneia bidens* (60%) and *Thoopterus suhaniahae* (18.86%). The highest diversity of fruit bats in Bawakaraeng mountain were in mixed garden (1453 m asl), primary forest (2000 m asl) and secondary forest with stream (1200 m asl). Moon phases affected the number of bats individual captured where the bats individual number captured were higher in dark moon phases than light moon phases.

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