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ALTITUDINAL DISTRIBUTION OF FRUIT BATS (PTEROPODIDAE) IN LORE LINDU NATIONAL PARK, CENTRAL SULAWESI, INDONESIA

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ABSTRACT - Between March 2000 and July 2001, we studied the distribution of fruit bats in Lore Lindu National Park, Central Sulawesi, Indonesia. Vegetation types and elevation belts between 350 and 2100 m a.s.l. were combined to characterize 17 habitat types, which were surveyed using standardized mist netting. Sixteen species of Pteropodidae (fruit bats) were identified in the park. Using an Euclidian distance dissimilarity index (EDD), the 16 species were clustered into four main groups. The results of cluster analysis were supported by Principle Component Analysis, PC1 and PC2 accounting for 71.94% and 27.39% of total variance, respectively. We suggest that PC2 primarily implies an altitudinal gradient, while PC1 is probably related to the gradient of humidity.

Key words: Chiroptera, elevation, diversity, habitat preferences

RIASSUNTO - ***Distribuzione altitudinale dei pipistrelli frugivori (Pteropodidae) nel Parco Nazionale di Lore Lindu, Sulawesi, Indonesia***. Tra Marzo 2000 e Luglio 2001, abbiamo studiato la distribuzione dei pipistrelli frugivori del Parco Nazionale di Lore Lindu (Sulawesi, Indonesia). Il tipo di vegetazione e le fasc di quota individuate tra 350 e 2100 m s.l.m. sono state combinate ad identificare 17 habitat, che sono stati monitorati tramite mist-nets. Sono state identificate 16 specie, che, tramite analisi dei cluster (EDD), sono state raggruppate in 4 gruppi principali. I risultati ottenuti sono stai confermati dall'Analisi delle Componenti Principali, per la quale PC1 e PC2 hanno spiegato, rispettivamente, il 71,94% e 27,39% della varianza complessiva. Riteniamo che PC2 sia legata ad un gradiente altitudinale, mentre PC1 probabilmente riflette un gradiente di umidità.

Parole chiave: Chiroptera, altitudine, diversità, preferenze ambientali

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INTRODUCTION

Sulawesi Island (Indonesia) retains high levels of endemism, particularly for mammals. As much as 30 % of the island's rats are endemic (Carleton and Musser 1984; Musser 1991), and even for more mobile mammals, such as pteropodids, levels of ca. 10% have been reported (Maryanto and Higashi in prep.). Furthermore, Sulawesi has been divided into several areas based on the distribution of endemic mammals, for instance Muridae (Musser and Dagosto 1987; Corbet and Hill 1992), squirrels (Musser et al. 2010), macaques (Fooden 1969; Supriatna 1996) and tarsiers (Shekelle and Laksono 2004), but not for Chiroptera. The geological history of the island probably played a major role in determining the high endemism rates of Sulawesi (Shekelle and Laksono 2004).

Sulawesi and neighbouring smaller islands are known to be rich in pteropodid (fruit bat) species. Bergmans and Rozendaal (1988) reported 21 species of Pteropodidae in Sulawesi and Sangihe/Sangir islands, to which, in their checklist of Indonesian mammals, Suyanto et al. (2002) added six further species, recorded on Selayar and Talaud islands (*Acerodon humilis* K. Andersen, 1909; *Cynopterus minutus* Miller, 1906; *C. sphinx* (Vahl, 1797); *Pteropus speciosus* K. Andersen, 1908; *P. pumilus* Miller, 1911). A new species, *Rousettus linduensis* Maryanto and Yani, 2003 has been recently described from the Lore Lindu area. However, none of these studies provided any information on the habitat preferences of these bats. In other parts of Southeast Asia, Medway (1972) and Heaney et al. (1989) reported that pteropodid species richness typically decreases with height above sea level. The same pattern has been reported for Lombok Island and the Lesser Sunda Islands of Indonesia (Gunnel et al. 1996; Kitchener 1998).

The distribution and diversity of bats are influenced by microclimate, elevation, habitat types and food resources (Maryanto and Yani 2003; Hodgkison et al. 2004; Campbell et al. 2007). In the Philippine archipelago, Heaney *et al*. (2005) showed that species associated with disturbed habitats tend to be widely distributed and show higher rates of gene flow between populations than species associated with rain forests, which tend to be endemic. This study was designed to provide detailed information on the distribution and habitat preferences of fruit bats in a mountainous region of Central Sulawesi.

MATERIALS AND METHODS

Lore Lindu National Park is the largest protected area on the island (ca. 231000 ha; Fig.1). The Park has a rugged topography, altitude ranging from 250 to 2340 m a. s. l. The area is mainly mountainous, 90% of the park being above 1000 m, while lower areas occur only next to the north-western park boundaries (Wirawan 1981). Ten land system use types and 11 major vegetation types have been distinguished (Maryanto and Yani 2001). According to Watling and Mulyana (1981), in Lore Lindu lowland forest species grow up to 1500 m a.s.l., the transition to mountain forest occurring at about 1000 m a.s.l. In contrast, Musser and Dagosto (1987) reported that, in Central Sulawesi, above 1300 m a.s.l. the lowland evergreen forest gives way to the lower mountain rain forest, and that this transition entails a reduction in mean canopy height, number of buttressed trunks and creepers, and ambient temperature. Biological diversity generally decreases with increasing elevation (Whitmore, 1984).

According to Maryanto and Yani (2001), vegetation cover was divided into 11 types: cloud forest (Cf), upper mountain forest (Um), mountain forest (Mo), lower mountain forest (Lm), lower mountain moist forest (Lmm), marsh (Ma), mixed garden (Mg), monsoon forest (Ms), swamp forest (Sf), lowland forest (Lf), and degraded lowland forest (Df). We divided the study area

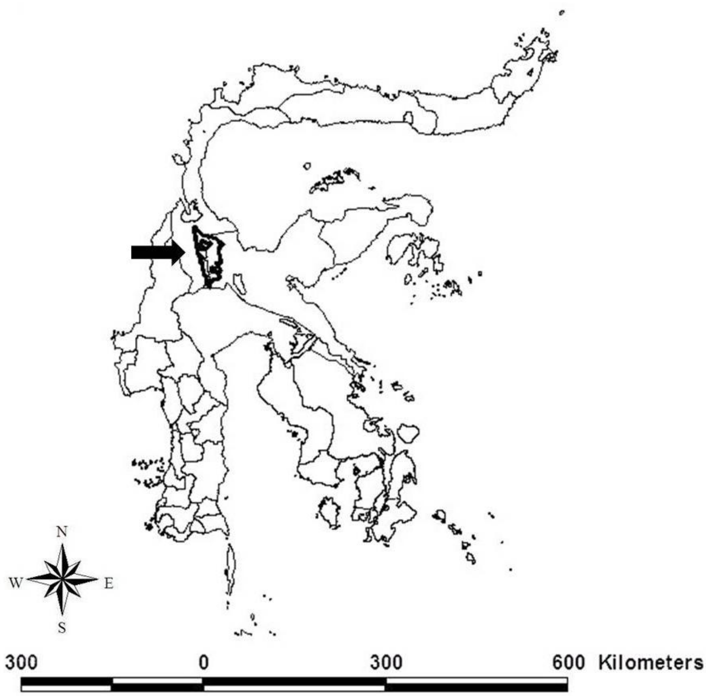

Figure 1 - Study area: Lore Lindu National Park, Central Sulawesi, Indonesia.

into seven altitudinal zones: 300-599 m (L2), 600-899 m (L1), 900-1199 m (M2), 1200-1499 m (M1), 1500-1799 m (H2), 1800-2099 m (H1) and above 2100 m a.s.l. (T). From the combination of the 11 vegetation types and 7 altitudinal zones, we obtained 17 habitats (Tab. 1). As an example, L2Ms is monsoon forest at 300-599 m a.s.l. Between March 2000 and July 2001, a total of 40 sampling sites were set up in the different habitats. Each sampling site was sampled for four nights by using four mist nets (lengths of 6, 9, 12, 18 m, each with a height of 2.7 m and four shelves). Mist nets were set up among the lower tree canopies and checked at 21:00 and 06:00 the following day. Survey data were entered into a Geographical Information System (GIS) (Arcview 3.2). Shannon-Wiener's index and Evenness (Krebs 1989) were used to compare bat assemblages. To define different clusters of species in relation to habitat variables, the Euclidian distance dissimilarity coefficient (EDD; Krebs 1989) was used and dendrograms were clustered by the Unweighted Pair Group Method with Arithmetic Mean (UPGMA). Cluster analyses and dendrograms of dissimilarity were produced using NTSYSpc 2.10. Principle Component Analysis (PCA) was employed to group bats according to habitat preferences (Tab. 1).

RESULTS

1. Composition and diversity of bat assemblages

A total of 3799 fruit bats were captured. The sample included 16 species and 11 genera (Tab. 1), 62% of Sulawesian fruit bat species. Dominant species (90.8% of the whole bat assemblage) included *Thoopterus nigrescens* (Gray, 1870) (2075 individuals), *Rou-*

settus celebensis K. Andersen, 1907 (1309 individuals), *Macroglossus minimus* (E. Geoffroy, 1810) (200 individuals), and *Cynopterus luzoniensis* (Peters, 1861) (187 individuals). Two species, *Rousettus (Boneia) bidens* (Jentink, 1879) and *R. linduensis* were rarely netted and were represented by only nine and four (0.241% and 0.11%) individuals each. Seven of the 16 species (44%), *C. luzoniensis, Dobsonia exoleta* K. Andersen, 1909, *R. (Boneia) bidens, R. celebensis, R. linduensis, Styloctenium wallacei* (Gray, 1866), and *Harpyionycteris celebensis* Miller and Hollister, 1921 are endemic to Sulawesi and adjacent islands (Kitchener and Maharadatunkamsi 1991; Corbet and Hill 1992).

The number of individuals captured for each altitudinal zone ranged from 48 (L2Ms) to 627 (M2Lm), due to variation in the abundance of dominant and eurytopic species. Shannon-Weiner's diversity curve was rather stable between 300 and 1500 m a.s.l. and then progressively decreased down to 0.18 at the highest elevations, while evenness ranged between 0.2 and 0.4 at 300-1800 m a.s.l. and then increased up to 0.53 at the highest elevations (Fig. 2). The decrease in Shannon-Weiner index at the summit of the mountain mainly depended on low species richness, bat assemblages being sharply dominated by *Thoopterus nigrescens* (Tab. 1).

2. Habitat preferences

The 16 species were clustered into groups at EDD =1.9, subgroups at EDD = 1.4 and subsets at EDD = 1.2 (Fig. 3).

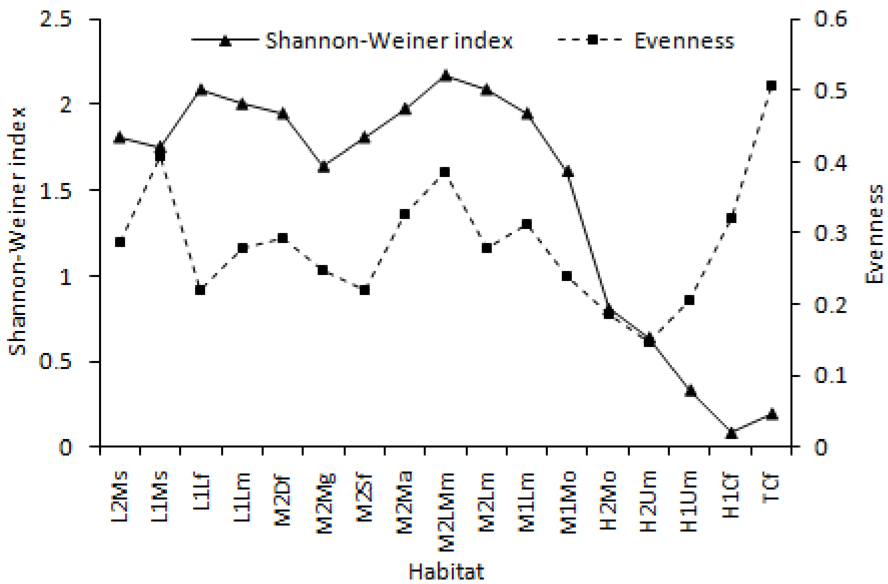

Figure 2 - Variation in both Shannon-Wiener's evenness indexes for fruit bat assemblages in different habitats in relation to the height a.s.l. (see the methods for habitat abbreviations).

Table 1. Number of bat species for 100 m² mistnet/four nights captured in different habitats (see methods for abbreviations) at Lore Lindu National Park, Central Sulawesi. Abbreviations of species names: *Chironax melanocephalus* (Chm), *Cynopterus brachyotis* (Cb), *C. luzoniensis* (Cl), *C. minutus* (Cm), *Dobsonia exoleta* (De), *Eonycteris spelaea* (Es), *Harpyonycteris celebensis* (Hc), *Macroglossus minimus* (Mm), *Nyctimene cephalotes* (Nc), *Pteropus alecto* (Pa), *Rousettus amplexicaudatus* (Ra), *R.* (*Boneia*) *bidens* (Rb), *R. celebensis* (Rc), *R. linduensis* (Rl), *Styloctenium wallacei* (Sw), *Thoopterus nigrescens* (Tn). (* = endemic species of Sulawesi and adjacent islands).

Habitat	*Chm*	*Cb*	*Cl* *	*Cm*	*De* *	*Es*	*Hc* *	*Nc*	*Mm*	*Pa*	*Sw* *	*Ra*	*Rb* *	*Rc* *	*Rl* *	*Tn*	Total species
TCf	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	73	2
H1Cf	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	254	3
H1Um	0	0	0	0	0	0	7	0	7	0	0	0	8	2	0	552	5
H2Um	5	1	1	1	0	0	4	0	6	0	0	0	0	10	0	271	8
H2Mo	0	0	0	0	1	0	5	1	17	0	1	0	0	21	0	274	7
M1Mo	7	1	1	2	1	0	6	0	14	0	0	0	0	34	0	116	9
M1Lm	7	1	2	0	0	0	1	2	17	0	1	0	0	20	0	55	9
M2Dl	0	11	19	8	5	0	0	2	14	0	0	2	0	137	0	48	10
M2Lm	11	26	62	16	10	0	9	3	18	0	2	0	0	292	0	180	11
M2Lmm	5	8	4	5	0	0	1	0	2	0	0	0	0	5	0	32	8
M2Ma	0	1	3	0	3	0	0	0	29	0	2	0	1	141	2	2	9
M2Mg	0	0	9	7	5	0	2	1	2	1	0	0	0	22	0	54	9
L1Lf	2	20	51	18	19	0	3	1	25	0	2	0	0	151	0	29	11
M2Sf	1	4	5	3	20	1	4	3	35	0	0	3	0	246	0	39	12
L1Lm	8	18	25	4	3	0	4	0	10	0	0	3	0	165	0	85	10
L1Ms	0	3	5	7	0	0	0	0	0	0	0	1	0	33	0	6	6
L2MS	0	5	0	3	1	0	0	0	1	0	1	2	0	30	0	5	8
Total	46	99	187	74	68	1	47	13	200	1	9	11	9	1309	2	2075	

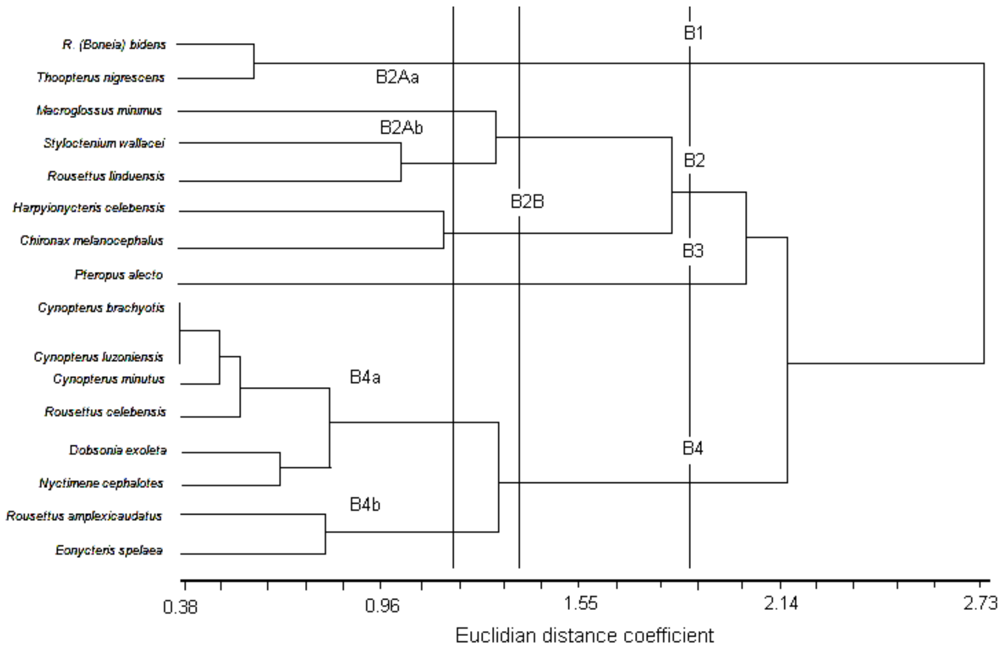

Figure 3 - Clustering of bats species captured at Lore Lindu National Park, Central Sulawesi by Euclidian dissimilarity index and UPGMA.

Group B1: Upper mountain association (1800-2100 m a.s.l.): consisted of *R. (Boneia) bidens* and *T. nigrescens*. The first is a rare and probably stenotopic species, while *T. nigrescens* is a eurytopic species. However, both of them are associated with the upper mountain forest.

Group B2: Lowland & mountain forest association (600-1800 m a.s.l.): consisted of two Subgroups. Subgroup B2A: Nectarivores, included *M. minimus*, *S. wallacei* and *R. linduensis*. In particular, *M. minimus* (Subset B2Aa) is a more specialized nectarivore than the other two species. *R. linduensis* was also captured in swamp forest at 930 m a.s.l. Subgroup B2B: included of *H. celebensis* and *C. melanocephalus* which are mainly frugivores (Corbet and Hill, 1992).

Group B3: included only one individual *Pteropus alecto*, a migrant species, which was captured in a marsh using mistnets that were set up about 9 m above the ground.

Group B4: Lowland and lower-mountain association (300-1200 m a.s.l.): consisted of two Subgroups, B4a: frugivores (*C. brachyotis, C. luzoniensis, C. minutus, R. celebensis, D. exoleta* and *N. cephalotes*); and B4b: nectarivores (*R. amplexicaudatus* and *E. spelaea*), mainly associated with lowland forests at 300-600 m a.s.l. (Corbet and Hill 1992). Except for *R. celebensis*, the eight species of Group B4 are widespread, indicating that endemic species are mainly distributed at high altitudes.

The results of clustering analysis are supported by PCA (Fig. 4, Tab. 2), for

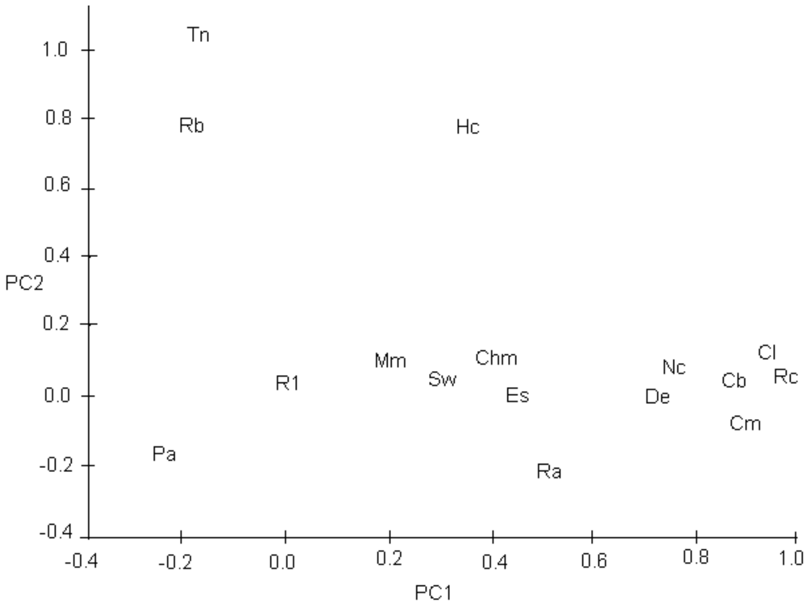

Figure 4 - Principle Component Analysis. PC1 and PC2 explain 71.94%, and 27.39% of total variance. Species name abbreviations are as in Table 1.

Table 2 - Factors' scores of Principle Component Analysis (see methods for abbreviations).

Habitat	Factor 1	Factor 2	Factor 3
TCf	-0.64449	-0.64143	-0.79372
H1Cf	-0.62667	0.63681	-0.91862
H1Um	-0.74569	2.85406	-0.42391
H2Um	-0.6208	0.84672	-0.48849
H2Mo	-0.78214	1.03824	0.57678
M1Mo	-0.74557	-0.54158	0.4933
M1Mo	-0.57096	-0.09283	0.35539
M2Sf	-0.00731	-0.07363	2.69962
M2Lm	2.47036	0.88395	-0.28367
M2Lmm	-0.47871	-0.97322	-1.14078
M2Dl	0.6102	-0.36647	0.20854
M2Ma	-0.98804	-0.7665	1.57638
M2Mg	0.82951	-0.35562	-0.20075
L1Ms	-0.20684	-1.08587	-1.06841
L1Lf	1.7756	-0.19181	0.52512
L1Lm	1.04591	-0.10739	-0.30729
L2MS	-0.31436	-1.06344	-0.80949

which the inspection of the eigenvalues revealed that PC1, PC2 and PC3 accounted for 71.94%, 27.39% and 0.34% of total variance, respectively. PC3 was subsequently excluded from the analysis. On PC1, the two dominant species, *T. nigrescens* and *R. celebensis*, are positioned on opposite margins, suggesting that PC1 was associated with some factor which is very different between mountain and lowland areas. It should be noted that the group of *T. nigrescens* and *R. (Boneia) bidens* is joined by *P. alecto* which was captured only in a marsh. Humidity being higher in mountain forests than in lowland forests, PC1 may be related to the gradient of humidity. For PC2, mountain species such as *T. nigrescens*, *R. bidens* and *H. celebensis* are positioned on the positive margin, while lowland species, *R. amplexicaudatus*, *C. minutus, P. alecto* and *R. celebensis* are on the negative one, suggesting that PC2 primarily describes an altitudinal gradient.

DISCUSSION

Our results agree with previous studies of fruit bats in suggesting that species richness decreases with altitude (Heaney et al. 1989; Medway 1972; Azlan 2003), although in the Rinjani Mountain area of Lombok richness declined between 200-400 m (Gunnel 1998). Bat abundance is thought to be influenced by habitat types and, consequently, food availability. Accordingly, the diversity of fruit trees decreases from lowland areas to mountain peaks (Whitmore 1984).

Over 450 species of fruit-bearing plants, including many economically important trees in tropical rain forests are associated with bats (Marshall, 1985; Fujita and Tuttle, 1991), which are considered to play a major role in the maintenance of many forest ecosystems. Shilton (1999) studied seed dispersal and pollination by bats in the Krakatau Islands and demonstrated rapid transit times, generally less than 30 minutes, whilst Tidemann et al. (1990) reported that in *Cynopterus sphinx* gut retention of food, including viable fig seeds, can be more than 12 hours. *Macroglossus*, *Eonycteris* and *Rousettus* bats mainly feed at flowers (Maryati et al. 2008; Soegiharto et al. 2010) and may play a major role in the pollination of several tree species in Sulawesi.

Six fruit bats species found in Lore Lindu National Park are widespread throughout Southeast Asia (*C. brachyotis, C. minutus, M. minimus*, *C. melanocephalus, R. amplexicaudatus* and *E. spelaea*). Heaney et al. (2005) suggested that widespread species occur also in disturbed habitats, whilst endemic species are rarely found far from primary rain forest. Accordingly, in our study area *R. amplexicaudatus*, *C. brachyotis, C. minutus* were strongly associated with disturbed lowland habitats. In contrast, the ability of these species to tolerate disturbed habitats and low humidity in highland habitats may be quite limited (Abdullah et al. 1997; Azlan 2000; 2003).

In Sri Lanka, *C. brachyotis* has been reported to be rare and restricted to forest habitat (Mapatuna et al. 2002), therefore this species is potentially threatened by deforestation. In contrast, in Peninsular Malaysia and Sarawak, *C. brachyotis* has two ‘morphs’: one usually found in forest and the other in disturbed habitats (Campbell et al. 2004; 2006; 2007). In Lore Lindu, *C. brachyotis* and *C. minutus* are sympatric with the endemic *R. celebensis and C. luzoniensis* in lowland or open habitats.

M. minimus has been reported to be a strong flier with wide distribution, from lowlands to upper mountain elevations (Suyanto 1994). In Lore Lindu, it was usually found in open secondary forests and was rather common in marsh and swamp forest. It is sympatric with the Sulawesian eurytopic species *R. celebensis* and *T. nigrescens*. *R. bidens* occurred at high elevations, *R. linduensis* and *M. minimus* at middle elevations and *R. amplexicaudatus* and *E. spelaea* in lowlands. In contrast, Bergmans and Rozendaal (1988) recorded *R. (Boneia) bidens* in lowland forests, between 200 and 500 m a.s.l., of Tambun and Lembeh Island. *Pteropus alecto* has so far been reported also for Bawean, Maluku and Irian (West Papua).

Based on this survey, habitat overlap and niche breadth deserve additional future studies to clarify the ecology and biogeography of bats in Sulawesi.

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REFERENCES

Abdullah M.T., Siswanto H., Widiyanto A., Setiabudi A., Firmansyah M. 1997. Abundance, diversity and distributional records of bats in disturbed habitats in Kalimantan Barat. Sarawak Museum Journal 51(72): 75-84.

Azlan J., Maryanto I., Kartono A.P., Abdullah M.T. 2003. Diversity, relative abundance and conservation of Chiropterans in Kayan Mentarang National Park East Kalimantan, Indonesia. Sarawak Museum Journal 58(79): 251-265.

Azlan J., Sharma R.S.K., Zakaria M. 2000. Species diversity and relative abundance of understory bats at Air Hitam Forest Reserve, Selangor, Malaysia. Malay. Nat. J. 54(1): 69-75.

Bergmans W., Rozendaal F.G. 1988. Notes on collections of fruit bats from Sulawesi and some off-lying islands (Mammalia, Megachiroptera). Zool. Verhandel. 248: 1-74.

Campbell P., Schneider C.J., Adnan A.M., Zubaid A., Kunz T.H. 2004. Phylogeny and phylogeography of Old World fruit bats in the *Cynopterus brachyotis* complex. Mol. Phylogenet. Evol. 33: 764–781.

Campbell P., Schneider C.J., Adnan A.M., Zubaid A., Kunz T.H. 2006. Comparative population structure of *Cynopterus* fruit bats in peninsular Malaysia and southern Thailand. Mol. Ecol. 15: 1-19.

Campbell P., Schneider C.J., Zubaid A., Adnan A.M., Kunz T.H. 2007. Morphological and ecological correlates of coexistence in Malaysian fruit bats (Chiroptera: Pteropodidae). J. Mammal. 88: 105–118.

Carleton M.D., Musser G.G. 1984. Murid rodents. In: Anderson S., Jones J.K. (eds), Orders and Families of Recent Mammals of The World. New York: Wiley 289-379.

Corbet G.B., Hill J.E. 1992. The mammals of the Indomalayan region: A systematic review. Natural History Museum Publications: Oxford University Press. London 488 pp.

Fooden J. 1969. Taxonomy and evolution of the monkeys of Celebes (Primates: Cercopithecidae). Bibliotheca Primatologica 10: 1-148.

Fujita M.S., Tuttle M.D. 1991. Flying foxes (Chiroptera: Pteropodidae): threatened animals of key ecological and economic importance. Conserv. Biol. 5: 455-463.

Gunnel A.C., Yani M., Kitchener D.J. 1996. Field Observation of *Macroglossus minimus* (Chiroptera: Pteropodidae) on Lombok Island Indonesia. In: Kitchener D.J., Suyanto A. Proceedings of the first International Conference on Eastern Indonesia-Australian Vertebrate Fauna. Manado, November 1994. 22-23: 127-146.

Heaney L.R., Heideman P.D., Rickart E.A., Utzurrum R.B., Klompen J.S.H. 1989. Elevation zonation of mammals in the central Philippines. J. Trop. Ecol. 5:259-280.

Heaney L.R., Walsh J.S.Jr., Peterson T. 2005. The roles of geological history and colonization abilities in genetic differentiation between mammalian populations in the Philippine archipelago. J. Biogeogr. 32: 229-247.

Hodgkison R., Balding S.T., Zubaid A., Kunz T.H. 2004. Habitat structure, wing morphology, and the vertical stratification of Malaysian fruit bats (Megachiroptera: Pteropodidae). J. Trop. Ecol. 20: 667–673.

Kitchener D.J. 1998. Biological Diversity In Eastern Indonesia Essentially Mammalian Perspective. Proceeding of the second international conference Indonesia-Australian vertebrate fauna. LIPI, Hidupan Liar, FFI, Directorate General of Tourism RI. 1-17.

Kitchener D.J., Maharadatunkamsi. 1991. Description of new species of *Cynopterus* (Chiroptera: Pteropodidae) from Nusa Tenggara, Indonesia. Rec. West. Aus. Mus. 15**:** 119-173.

Krebs J.C. 1989. Ecology methodology. New York Harper and Row 654 pp.

Mapatuna Y., Gunasekera M.B., Ratnasooriya W.D., Goonesekere N.C.W., Bates P.J.J. 2002. Unravelling the taxonomy status of the genus *Cynopterus* (Chiroptera: Pteropodidae) in Sri lanka by multivariate morphometrics and mitochondrial DNA. Mamm. Biol. 67: 321-337.

Marshall A.G. 1985. Old world phytophagous bats (Megachiroptera) and their food plants: a survey. Zool. J. Lin. Soc. 83: 351-369.

Maryanto I., Higashi S. (in prep). Comparison of zoogeography among Indonesian rats, fruit bats and insectivorous bats in Indonesia.

Maryanto I., Yani M. 2001. Small mammal survey from Lore Lindu National Park Central Sulawesi, Indonesia. Unpublished report to The Nature Conservancy 93 pp.

Maryanto I., Yani M. 2003. The new species of the Rousett bat from Lore Lindu National Park, Central Sulawesi, Indonesia. Mamm. Study 28: 111-120.

Maryati, Kartono A. P., Maryanto I. 2008. Kelelawar pemakan buah sebagai polinator yang diidentifikasi melalui polen yang digunakan sebagai sumber pakannya di kawasan sector Linggarjati, Taman Nasional Ciremai Jawa Barat. J. Biol. Indo. 4(5): 335-347.

Medway L. 1972. The distribution and altitudinal zonation of birds and mammals on Gunung Benom. Bull. Br. Mus. Nat. Hist. 23: 103-154.

Musser G.G, Durden L.A., Holden M.E., Light J.E. 2010. Systematic review of endemic Sulawesi squirrels (Rodentia, Sciuridae), with descriptions of new species of associated sucking lice (Insecta, Anoplura), and phylogenetic and zoogeographic asessments of sciurid lice. Bul. Am. Must. Nat. Hist. 339: 1-260.

Musser G.G. 1991. Sulawesi Rodents: Descriptions of New Species of *Bunomys* and *Maxomys* (Muridae, Murinae). Am. Mus. Novit. 3001: 1-41.

Musser G.G., Dagosto M. 1987. The identity of *Tarsius pumilus*, a pigmy species endemic to the montane mossy forest of Central Sulawesi. Am. Mus. Novit. 2867: 1-53. M

Shekelle M., Laksono S.M. 2004. Strategi Konservasi di Pulau Sulawesi dengan menggunakan Tarsius sebagai flagship spesies. Biota 9: 1-10.

Soegiharto S., Kartono A.P., Maryanto I. 2010. Pengelompokan kelelawar pemakan buah dan nektar berdasarkan karakteristik jenis pakan polen di Kebun Raya Bogor Indonesia. J. Biol. Indo 6(2): 225-235.

Supriatna J. 1996. Gene Flow of the Two Hybridised Sulawesi Macaques: *Macaca tonkeana* and *M. maurus*. Proceeding of the first International Conference on Eastern Indonesia-Australia vertebrate fauna, Manado, November 1994, 22-26: 23-29.

Suyanto A. 1994. Morphological and genetic variation of island populations of *Macroglossus* spp. M.Sc. thesis, The University of Western Australia.

Suyanto A., Yoneda M., Maryanto I., Maharadatunkamsi Sugardjito J. 2002. Checklist of the Mammals of Indonesia: Scientific Names and Distribution Area Tables in Indonesia Including CITES, IUCN and Indonesian Categories for Conservation. Bogor: LIPI-JICA-PHKA. 63 pp.

Tidemann C.R., Kitchener D.J., Zann R.A., Thornton I.W.B. 1990. Recolonization of the Krakatau Island and the adjacent areas of West Java, Indonesia, by bats (Chiroptera) 1883-1986. Phil. Trans. R. Soc Lond. B. 328: 123-130.

Watling D., Mulyana Y. 1981. Lore Lindu National Park Management Plan 1981-1986. A Report for the Directorate of Nature Conservation Republic of Indonesia. Bogor.

Whitmore T.C. 1984. Tropical rain forest of the Far East. Claredon Press. Oxford. 282 pp.

Whitmore T.C. 1990. An Introduction to tropical rain forest. Claredon Press. Oxford.

Wirawan N. 1981. Ecological survey of the proposed Lore Lindu National Park, Central Sulawesi. Prepared for World Wildlife Fund Project 1526. Universitas Hasanuddin, Ujung Pandang, Sulawesi 84 pp.