Research article

Distribution of rats at Lore Lindu National Park, Central Sulawesi, Indonesia

IBNU Maryanto[1]*, SITI NURAMALIATI Prijono[1] and MOHAMAD Yani[2]

[1]*Zoology Division, Research Centre in Biology-Indonesian Institute of Science (LIPI), Jl. Raya Cibinong KM 46 Bogor, Indonesia. *email: ibnu_mar@yahoo.com*

[2]*Jl. Gotong Royong Gg. Jeruk 6/2. Komplek Kebun Jeruk, Pejeruk, Ampenan, Lombok, Indonesia*

ABSTRACT. Extensive surveys for rodents were undertaken within Lore Lindu National Park, Central Sulawasi, Indonesia from March 2000 to July 2001. A total of 40 sites were sampled in 17 habitats throughout the park. Capture rates were generally low with a total of 309 rats caught in 32,000 trap-nights giving an average of 104 captures per trap-night. Twenty species of rats from eight genera were caught, representing 46% of the known Sulawesian rat fauna. Dominant species in the sample caught were *Rattus hoffmanni* (16.56% from 314 individuals captured), *Bunomys chrysocomus*, *B. prolatus*, *B. penitus*, *Taeromys celebensis* and *Rattus marmosurus*. Several rarely recorded rodents that inhabit mountain tops were captured in this survey, namely *Melasmothrix naso*, *M. rhinogradoides* and *Lenomys meyeri*. The distribution of many of the rodents was heavily affected by elevation and human disturbance. This was quantified through the Principle Component Analysis, with PC1, PC2 and PC3 accounting for 61.63%, 15.12% and 11.34% of total variance, respectively. PC1 appears to be weighted heavily by altitude. *Maxomys hellwaldii*, *Bunomys prolatus* and *Rattus hoffmanni*, which prefer lower montane habitats, were located on positive margin while *Taeromys punicans*, *Bunomys penitus*, *Melasmothrix rhinogradoides*, *M. naso*, *Lenomys meyeri* and *Maxomys wattsi*, prefer mountain tops, were located on the negative margin. PC2 mostly implies a gradient of human impact. *Paruromys dominator* and *Bunomys penitus* preferring highland natural forests were situated on the positive margin while *Rattus exulans*, *Taeromys arcuatus* and *T. hamatus*, preferring mix garden, marshes and lower montane forest were positioned on the negative margin. We were unable to make any inferences to PC3, partly due to its low contribution of 11.34% to the total variance.

Keywords: Rats, distribution, Lore Lindu National Park Sulawesi, Indonesia.

INTRODUCTION

The distribution and diversity of rats are influenced by microclimate, elevation, habitat types and food resources. Heaney *et al*. (2005) on the study of Philippine bats and rodent stated that species associated with disturbed habitats, tends to be widely distributed in South East Asia. Kitchener & Yani (1998) on the study of endemic species of *Rattus haenaldi* from Flores Island and *Melomys bannisteri* (Kitchener & Maryanto, 1994) from Kai Island indicated that they survive well in undisturbed and disturbed habitat, respectively.

The Indonesian island of Sulawesi has a unique mammalian fauna that is not only particularly rich in species, but features a very high level of endemism (Maryanto, 2005). These arguments seem to be supported in Sulawesi where the endemicity is as high as 30% in rats with low migration ability, but only 10% in fruit bats (Megachiroptera) with high migration ability (Carletton & Musser 1984; Musser 1991). Sulawesi is evidently divided into several areas of mammalian endemism especially for the murid rodents (Musser & Dagosto, 1987, Corbet & Hill, 1992), macaques (Supriatna, 1996) and tarsiers (Shekelle & Laksono, 2004).

One of the biggest National Parks in Sulawesi, Indonesia, is Lore Lindu, having a total area of approximately 231,000 ha. The Park has a rugged topography with an altitudinal range of 250-2340 m above sea level. There are ten land system types and 11 major vegetation types (Taman Nasional Lore Lindu 2001). Although montane forest species occurs as high as 1500 m, the transition of those two major types of the vegetation occurs at about 1000 m above sea level (Watling & Mulyana 1981). Furthermore, Bynum (1999) classified that the lowland forest in Lore Lindu has five significant variables used to indicate anthropogenic disturbance in the low land. Those are stumps, exotic trees, rattan>3 meters, rattan<3 meters, and moss line. Musser & Dagosto (1987) stated that in the altitude of more than 1300 m in Central Sulawesi, the lowland evergreen forest is characterized by lower montane rain forest, lower canopy height, species diversity, buttressed trunks, woody climbers and ambient temperature. Watling & Mulyana (1981) reported that most of Sulawesi's endemic mammals and 83% of its avifauna have been recorded in the Park. Several important mammal populations were known to exist in this Park, including: Dwarf Mountain Anoa, *Anoa quarlesi*; Babyrousa, *Babyroussa babyrusa*; Tarsiers, *Tarsius pumilus*, *T. dianae*, and *T. spectrum*; Giant Sulawesi Civet, *Macrogalidia muschenbroecki*; and Sulawesi Cuscus, *Strigocuscus celebensis*. Three species of murid rodents, *Margaretamys elegans*, *Melasmothrix naso* and *M. rhinogradiodes*, were recorded only from Lore Lindu National Park (Musser & Dagosto, 1987).

In this study we characterized habitat preference of rat species in Lore Lindu National Park, Central Sulawesi. There has been studies on rats in Sulawesi but studies on its altitudinal distribution is poor (Musser, 1984, 1991 Musser & Dagosto, 1987; Suyanto *et al*., 2002). This study is designed to provide detailed information on the micro-distribution of rats in the Park.

METHODOLOGY

The ecological study on rats was carried out from March 2000 to July 2001 in Lore Lindu National Park (LLNP), Central Sulawesi Indonesia, of approximately 231,000 ha (Figure 1). A total of 40 sites were set up at different altitudes and vegetations. Vegetations were divided into 11 types: cloud forest (Cf), upper montane forest (Um), montane forest (Mo), lower montane forest (Lm), lower montane moist forest (Lmm), marsh (Ma), mixed garden (Mg), monsoon forest (Ms), swamp forest (Sf), lowland forest (Lf), and degraded lowland forest (Df). These vegetation types lay on an altitudinal range of 300 to >2100 meters a.s.l.. The altitude was divided into seven 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 (T). The vegetation types and altitudinal zones were combined into 17 categories.

The rats were trapped using two types of traps, namely small wire Kasmin cage traps with dimensions of 28x12x12 cm; and standard snap traps with dimensions of 8x15cm to capture the largest rat species weighing up to 500 grams. Ten transect lines of 100 m long were set up at each habitat at intervals of ca. 20 m. On each line, 20 traps (10 cage traps and 10 snap traps)

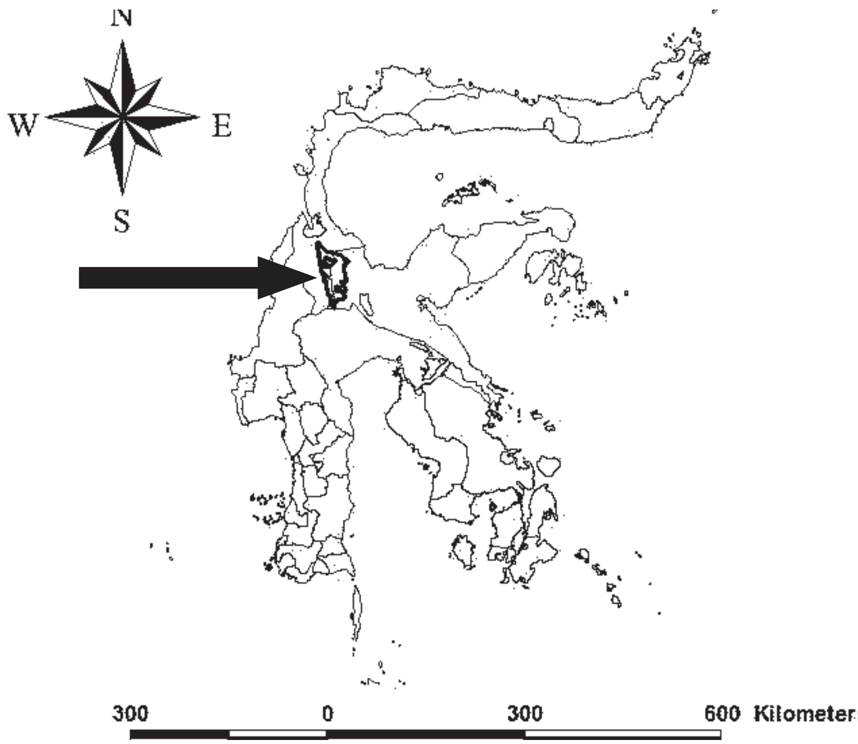


Figure 1. Locality of rat survey in Lore Lindu National Park-Central Sulawesi, Indonesia.

were alternately put at intervals of 5 m. Hence, the total number of traps per site was 200 traps. Kitchener *et al*. (1997) argued that a substantial reduction in rate of capturing additional mammal species over a weekly period is required in Indonesia. Hence, the traps were placed on the ground for four nights giving a standard trapping effort of 800 trap nights per habitat. We used two types of baits: a lightly roasted coconut and dried fish. These were placed alternately in each trap type. Coordinates of the trap sites were geolocated using GPS units, and the altitudes of the plot were recorded.

The results of the survey were entered into a Microsoft Access database linked to an Arcview 3.2 GIS geographical information system. For diversity measures which variably reflect both the number and relative abundances of species in a community, Shannon-Weiner diversity index and Evenness were used in this study, with an Ecological Methodology computer package (Krebs 1989). The cluster analyses and dendrograms of dissimilarity were produced using calculations from NTSYSpc 2.10p. To investigate the extent to which species form discrete clusters with a dependency on different variables, a Euclidian distance dissimilarity coefficient was used; dendrograms were clustered by UPGMA and grouping of rats used the Principle Component Analysis (PCA) (SPSS pc 2006).

RESULTS

Fauna and diversity

We experienced very low capture rates for rats, although we established a huge number of trapping effort (32000 trap-nights). A total of 309 rats were caught in on average of 104 trap nights (a single trap night is one trap set for one night required to capture a single individual rat). A total of 309 individuals representing 20 species from eight genera or 46% of Sulawesian rats were captured in this survey (Table 1). These species are *Bunomys chrysocomus (Bch), B. penitus (Bpn), B. prolatus (Bpr), Lenomys meyeri (Lmy), Margaretamys elegans (Mel), Maxomys helwaldii (Mhe), Maxomys muschenbroechii (Mmu), Maxomys wattsi (Mwa), Melasmothrix naso (Mna), Melasmothrix rhinogradoides (Mri), Paruromys dominator (Pdo), Rattus exulans (Rex), Rattus hofmanni (Rho), Rattus marmosurus (Rma), Rattus rattus (Rra), Rattus* sp. cf. *marmosurus (Rxa), Taeromys arcuatus (Tar), Taeromys celebensis (Tce), Taeromys hamatus (Tha), Taeromys punicans (Tpu).*

Dominant species were *Rattus hoffmanni*, *Bunomys chrysocomus, B. prolatus, Taeromys celebensis*, *B. penitus*, and *R. marmosurus*. Even very rare species such as *Melasmothrix naso, M. rhinogradoides* and *Lenomys meyeri* inhabiting mountain-top area were captured in this survey. Out of the 20 species captured, 18 species are endemic to Sulawesi.

The number of individuals captured altitudinally (1000traps/night) fluctuated from five (M2Df) to 113 (M2Lm) mostly due to the fluctuation in the number of individuals of dominant and eurytopic species. It is likely that the fluctuation in sample size brought about the fluctuation in the Shanon-Weiner diversity index and evenness (Figure 2) which fluctuated from 0.72 (M2Df) to 3.04 (M1Mo) and from 0.44 (H2Mo) to 1.0 (L2Ms), respectively. However, the curve of Shannon-Weiner index overall ascended while the curve of Evenness descended toward higher altitude. The overall increase of Shannon-Weiner index toward higher altitude considerably depended on the increase of species richness at high altitude.

Habitat preference

Using the Euclidian distance dissimilarity index (EDD), the 20 species were clustered into four groups at EDD=1.98 and subgroups at EDD= 1.6 as follows (Figure 3).

Table 1. Acumulated number of individual of each rat species for 1000 trap/night(*= non endemic species to Sulawesi) captured at each habitat. Abbreviations of species name, see text.

		Species																			
Elevation	Vegetation	Habitat	Bch	Bpn	Bpr	Lmy	Mel	Mhe	Mmu	Mwa	Mna	Mri	Pdo	Rex*	Rho	Rma	Rra*	Rxa	Tar	Tce	Tha	Tpu
>2100 (T)	Cloud (Cf)	TCf	0	3	0	1	0	0	0	0	0	1	4	0	4	3	0	3	0	0	1	1
1800-2099 (H1)	Cloud (Cf)	H1Cf	1	9	0	0	3	0	0	3	1	0	10	0	13	5	0	0	0	4	0	0
1800-2099 (H1)	Upper montane (Um)	H1Um	0	16	0	0	0	0	0	0	0	0	6	0	3	6	6	0	0	0	0	0
1500-1799 (H2)	Upper montane (Um)	H2Um	0	10	2	0	0	0	0	0	0	0	10	0	0	0	0	2	0	2	0	2
1500-1799 (H2)	Montane (Mo)	H2Mo	13	3	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	28	0	0
1200-1499 (M1)	Montane (Mo)	M1Mo	8	5	3	0	3	0	0	0	0	0	4	0	3	5	0	1	0	1	1	0
1200-1499 (M1)	Lower montane (Lm)	M1Lm	0	1	0	0	0	0	0	0	0	0	1	0	2	1	0	1	0	1	1	0
900-1199 (M2)	Degraded (Df)	M2Df	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
900-1199 (M2)	Lower montane (Lm)	M2Lm	13	3	27	0	0	11	1	0	0	0	5	0	24	14	0	2	0	13	0	0
900-1199 (M2)	Lower m. moist (Lmm)	M2Lmm	1	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0
900-1199 (M2)	Marsh (Ma)	M2Ma	1	0	0	0	0	0	0	0	0	0	0	1	4	3	0	0	3	3	0	0
900-1199 (M2)	Mix garden (Mg)	M2Mg	1	0	0	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0	0
600-899 (L1)	Lower montane (Lm)	L1Lm	25	1	30	0	0	12	0	0	0	0	1	0	16	0	0	4	0	11	4	0
900-1199 (M2)	Swamp (Sw)	M2Sw	1	0	0	0	0	1	0	0	0	0	1	1	3	5	0	4	0	5	0	0
600-899 (L1)	Low land (Lf)	L1Lf	4	1	4	0	0	0	0	0	0	0	0	4	3	8	0	3	0	0	0	0
600-899 (L1)	Moonson (Ms)	L1Ms	0	0	0	0	0	5	0	0	0	0	0	3	5	0	3	0	0	0	0	0
300-599 (L2)	Moonson (Ms)	L2Ms	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0

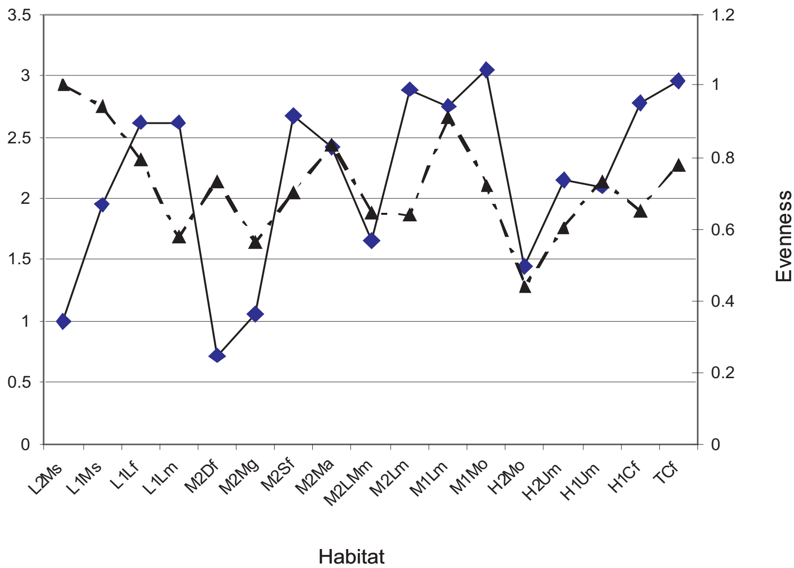


Figure 2. Shanon-Weiner index (full line) and eveness (dot line) of rats biodiversity in Lore Lindu National park, Central Sulawesi. For the abbreviations of habitas, see material and methods

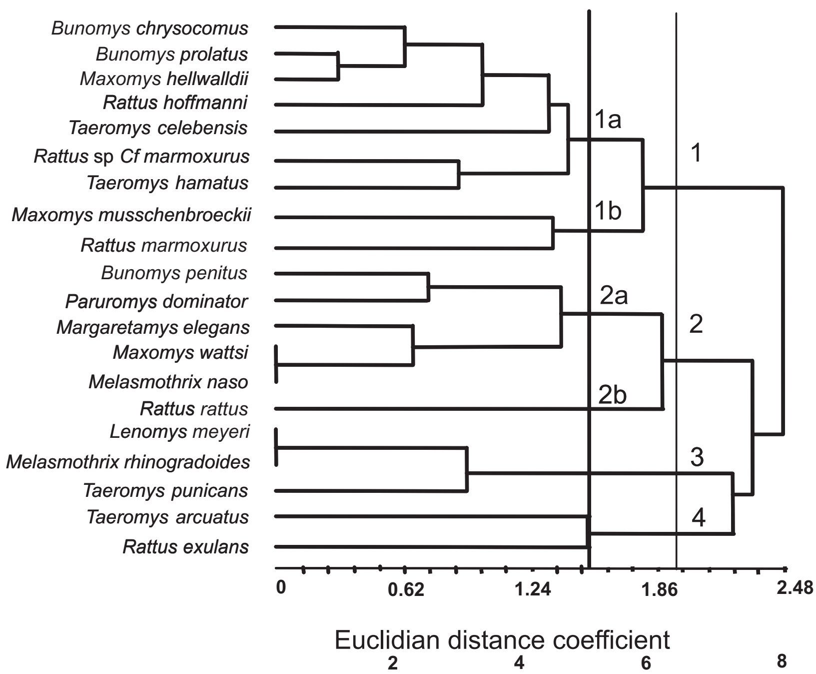


Figure 3. Clustering of rats species captured at Lore Lindu National Park, Central Sulawesi. Euclidian dissimilarity index and UPGMA were employed.

Group R1 consists of subgroup R1a: *Bunomys chrysocomus, B. prolatus, Rattus hoffmanni,* R.sp. cf. *marmosurus, Maxomys hellwaldii, Taeromys celebensis* and *T. hamatus*; and subgroup R1b: *Maxomys muschenbroechii* and *R. marmosurus*. Although eurytopic species such as *R. hoffmanni, B. chrysocomus, Bunomys prolatus* and *R. marmosurus* were included, most species of this group preferred lowland habitats.

Group R2 consists of subgroup R2a: *Bunomys penitus, Paruromys dominator, Margaretamys elegans, Maxomys wattsi* and *Melasmothrix naso*; and subgroup R2b: *Rattus rattus*. The species of this group preferred forests from 600 m to1800 m elevation. *Rattus rattus* (Subgroup R2b) is not endemic to Sulawesi but is widely distributed in Indonesia depending on artificial transports.

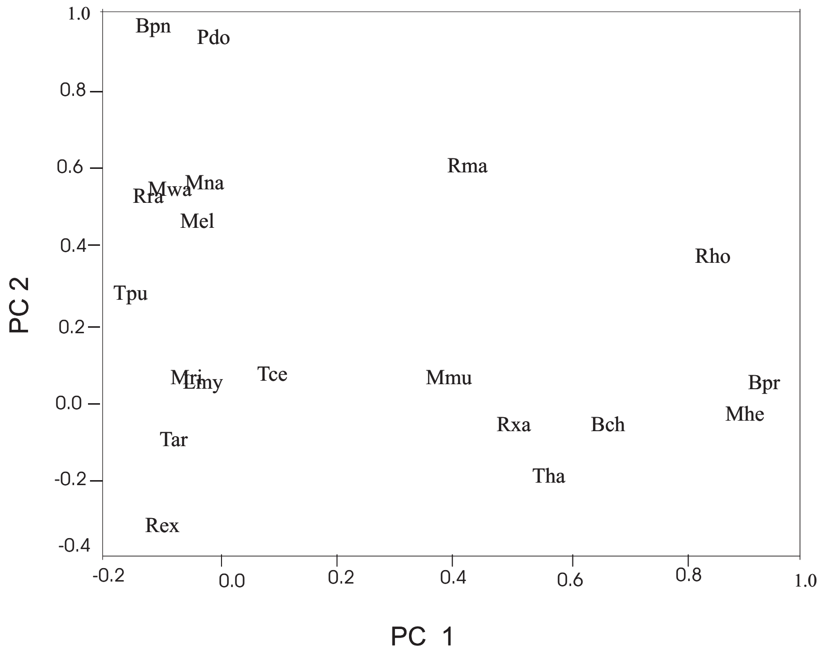
Group R3 consists of *Lenomys meyeri, Melasmothrix rhinogradoides* and *Taeromys punicans*. This group consists of rare species preferring top-mountain area.

Group R4 consists of *Rattus exulans* and *Taeromys arcuatus*. The species of this group preferred mix garden and/or marsh near residence. *Rattus exulans* is common across Indonesian Archipelago.

The results of clustering analysis were almost supported by PCA (Figure 4), where PC1, PC2 and PC3 accounted for 61.63%, 15.12% and 11.34% of total variance, respectively. On PC1, *Maxomys hellwaldii, Bunomys prolatus* and *Rattus hoffmanni* preferring lower montane were located on positive margin while *Taeromys punicans, Bunomys penitus, Melasmothrix rhinogradoides, M. naso, Lenomys meyeri, Maxomys wattsi* preferring mountain tops were located on negative margin, suggested that PC1 considerably implies altitudinal gradient. On PC2, *Paruromys dominator* and *Bunomys penitus* preferring highland natural forests were situated on positive margin and *Rattus exulans, Taeromys arcuatus* and *T. hamatus* preferring mix garden, marsh and lower montane were positioned on negative margin, indicated that PC2 mostly implies the gradient of human impact. We could not suggest any implication of PC3, partly due to the contribution of this component as low as 11.34% of total variance. In general, the distribution pattern of rats in this park appears to be mainly due to altitude and partly by human impact.

DISCUSSION

There are great difficulties in documenting gradational trends of rats, due to low capture rates. For example, 104 trap nights on the average were required to capture a single individual rat. In comparison to other tropical Asian studies, it was particularly difficult to capture rats in the Lore Lindu National Park. For example, Medway (1972) reported that, on Gunung Benom, West Malaysia at 300-2400 m a.s.l, 50 trap nights were required to capture a small mammal (from 5,777 trap nights). Heaney *et al.* (1989) required 30 trap nights (from 3,485 trap nights) on Leyte Island, Phillipines, at 300-900 m a.s.l., 11 trap nights (from 3,231trap nights) on Guisayawan, Negros Island, Philippines at 0-1500 m a.s.l. Tam *et al.* (2002) required 75 trap nights (from 17,512 trap nights) on tropical forest of Vietnam. The only other figures available from Indonesia, were reported by Kitchener & Yani (1998), who needed an average of 117 trap nights for a small mammal at Ranaka Mountain, Flores Indonesia. Kitchener & Yani (1998) showed that between 1000 and 1200 m a.s.l, the species richness of ground mammals was high, due to the abundance of introduced mammals but declined rapidly at higher elevations and stayed low over 2000 m a.s.l. The Shannon-Weiner diversity and Evenness indices on our present study fluctuated with habitats. The increase in the Shannon-Weiner index toward higher altitude considerably depended on the increase of species richness at high altitude, while the curve



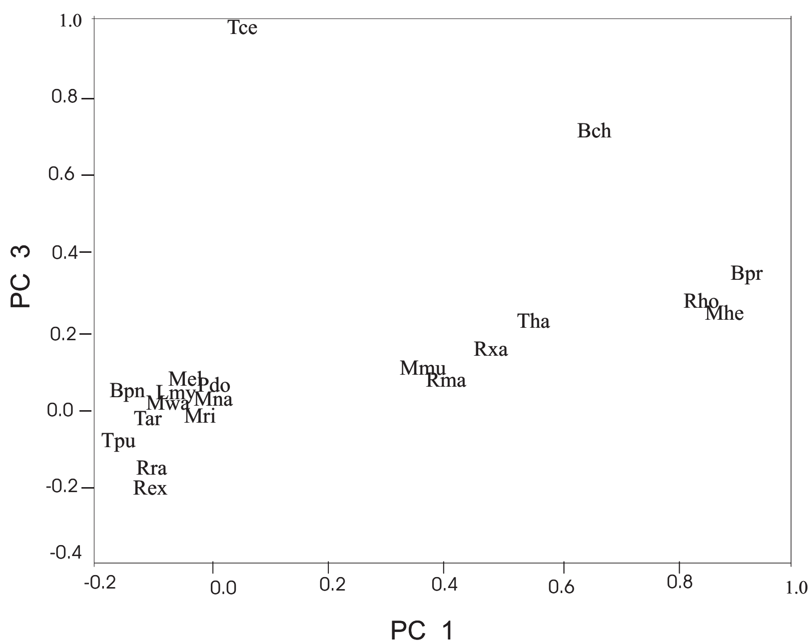


Figure 4. Principle component analysis for rats species captured at Lore Lindu National Park, Central Sulawesi. PC1, PC2 and PC3 showed total variance of 61.63%, 15.12% and 11.34%, respectively. Abbreviations of species name as follows: *Bunomys chrysocomus* (Bch), *B. prolatus* (Bpr), *B. penitus* (Bpi), *Lenomys meyeri* (Lmy), *Margaretamys elegans* (Mel), *Maxomys muschenbroechii* (Mmu), *M. hellwaldii* (Mhe), *M. wattsi* (Mwa), *Melasmothrix naso* (Mna), *Melasmothrix rhinogradoides* (Mri), *Paruromys dominator* (Pdo), *Rattus exulans* (Rex), *R. hoffmanni* (Rho), *R. marmosurus* (Rma), *R.*sp.cf. *marmosurus* (Rxa), *Rattus rattus* (Rra), *Taeromys arcuatus*, *Taeromys hamatus* (Tha), *T. celebensis* (Tce), *Taeromys punicans* (Tpu).

of Evenness index descended toward higher altitude. Abramsky & Rosenweig (1984) and Kitchener *et al*. (1987) showed that species diversity of rodents in the arid region was associated with rainfall and habitat types. The rainfall on our study locations ranged from 1000 to more than 2500 mm, and 63% of rats we caught were located in area with rainfall criteria of more than 2000 mm. Furthermore, Chauhan (2002) indicated that diversity associated with different types of vegetation and rodent population was synchronous with the source of palatable fruits and seeds, especially on the bamboo flowering season.

In these habitats, the animals' seemed to be general feeders in food selection. Wall (2003) argued that olfaction is important in rodents for foraging, predator avoidance, and communication. Rodents have difficulties with detecting buried seeds in dry soil but have higher foraging success when the soil is moist. Rodents are likely to benefit from the similar effect of relative humidity.

On the study of Sulawesian rat, Musser (1991) indicated that widespread and common forest rat species in Sulawesi is *Rattus hoffmani*. This species is distributed in all habitat types in Lore Lindu NP and abundant in the lower montane between altitudes of 900-1200 m. Based on our observation at this park and at Tomohon-Northern Sulawesi, *Rattus exulans* or *R. rattus* are easily caught in the plantation as they are normally widespread in the western area of the Wallace Line. *Rattus exulans* has a huge geographical range that extends from Bengladesh to Irian and New Zealand and it is closely associated with human activities (Aplin *et al*., 2002). This could be due to the eurytopic Sulawesian species of *R. hoffmani* potentially competing with *Rattus exulans* especially in the plantation or disturbed forest.

In addition, *Rattus marmosurus* is one of eurytopic species in Sulawesi and was indicated as lowland species category in our analysis. Aplin *et al*. (2002) argued that the endemic *Rattus marmosurus* is one of the members in the archaic group. They, in general, show no close relationship to other *Rattus* species in adjacent geographical areas. These are probably descendants of early waves of dispersal through the region.

The cluster analyses showed that *Bunomys prolatus* and *B. chrysocomus* apparently have a distributional relationship somewhat similar to study in Tambosisi mountain (100 km eastern of this park) by C.H. Watts; however, he did not capture *Bunomys penitus* in that mountain (Musser, 1991). In Lore Lindu National Park, *Bunomys penitus*, *Paruromys dominator*, *Margaretamys elegans*, *Maxomys wattsi* and *Melasmothrix naso* chose forests at 600 m to1800 m a.s.l as reported by Musser & Dagosto (1987). It is clear that small ground mammal elements of the fauna in the montane forest on flanks Tabusisi are very similar to that at Lore Lindu NP but differ to that recorded by Musser from Noki Lalaki (Musser 1991).

ACKNOWLEDGEMENTS

We would like to express our gratitude to Ir. Banjar Yulianto Laban, the Director of Lore Lindu National Park, and his staff for providing us with substantial assistance in the field. We also thank Mr. Duncan Neville, The Nature Conservancy Program Manager at Palu, and Dr. Darrell J. Kitchener, The Nature Conservancy Director of Conservation, for their organization of the mammal survey in Lore Lindu National Park. Appreciations are extended to our field assistant, Mohamad Annas, who helped us in developing the trapping procedures used in the field. We are also indebted to Dr. R.A. How (Western Australian Museum), Dr. D. J. Kitchener and Prof S. Higashi (Hokkaido University), Dr. Anggoro Prasetyo (MZB-LIPI) and Dr. Glen Hoye (Bat Australian Researcher) who commented on the analyses and critical reading of the manuscript. We appreciate the help of an anonymous person who have commented on the English language of this paper. A final word of thanks goes to the TNC and USAID for their sponsorship in our study.

REFERENCES

Abramsky, Z & M.L. Rosenweig. 1984. Tilman's predicted productivity-diversity relationship shown by desert rodents. *Nature Lon.* 309:150-151.

Aplin, K.P., T. Chesser & J.T. Have. 2002. Evolutionary biology of the genus Rattus: profile of an archetypal rodent pest. In: G.R. Singleton, L.A. Hinds, C.J. Krebs, & D.M. Spratt (eds.). *Rats, Mice and People: Rodent Biology and Management*. Canberra: ACIAR, pp. 487-498.

Bynum, D.Z. 1999. Assessment and monitoring of anthropogenic disturbance in Lore Lindu National Park, Central Sulawesi, Indonesia. *Tropical Biodiversity* 6 (1&2): 43-57.

Carletton, M.D. & G.G. Musser. 1984. Murid rodents. In: Anderson, S. & J.K. Jones (eds.) *Orders and families of recent mammals of the world*, pp. 289-379. New York: Wiley.

Chauhan, N.P.S. 2002. Observation of bamboo flowering and associated increases in rodent populations in the north-eastern region of India. In: G.R. Singleton, L.A. Hinds, C.J. Krebs, & D.M. Spratt (eds). *Rats, mice and people: Rodent biology and management Canberra*: ACIAR,, pp. 267-270.

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

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

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

Kitchener, D.J., Boeadi & M.H. Sinaga. 1997. The mammals of the Freport Contract of work region, Irian Jaya: Results from the survey of 14 February-6 March 1997. Unpublished report to Freport, Jakarta.

Kitchener, D.J. & I. Maryanto. 1994. New species of *Melomys* (Rodentia, Muridae) from Kai Besar. I. Maluku Tengah, Indonesia. *Record of the Western Australian Museum* 16 (3): 427-436.

Kitchener, D.J., Y.X. Wang, A. Gradley, R.A. How, & J. Dell. 1987. Small mammals and habitat disturbance near Kunming, Sout-West China. *Indo-Malayan Zoology* 4: 161-186.

Kitchener, D.J. & M. Yani. 1998. Small mammals non Volant terrestrial mammals diversity along an altitudinal gradient at Gunung Ranaka Flores island Indonesia. *Tropical Biodiversity* 5 (2):155-159.

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

Maryanto, I. 2005. Taxonomy and zoogeography of rats and bats on Indonesia Archipelago. Ph.D Thesis. Graduate School of Environmental Earth Science Hokkaido University.

Medway, L. 1972. The distribution and altitudinal zonation of bird and mammals on Gunung Benom. *Bulletin British Museum History* 23: 103-154.

Musser, G.G. 1984. Identities of subfossil rats from caves in southwestern Sulawesi. *Modern Quaternary Research in Southeast Asia* 8: 61-94.

Musser, G.G. 1991. Sulawesi Rodents: Descriptions of new species of *Bunomys* and *Maxomys* (Muridae, Murinae). *American Museum Novitates* 3001: 1-41.

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

Shekelle, M. & S.M. Laksono. 2004. Strategi konservasi di Pulau Sulawesi dengan menggunakan tarsius sebagai flagship spesies. *Biota* 9: 1-10.

Supriatna, J. 1996. Gene flow of the two hybridised Sulawesi Macaques: *Macaca tonkeana* and *M. maurus*. Proc. of the first international conference on Eastern Indonesia-Australia vertebrate fauna, Manado, Indonesia Nov 22-26, 1994 (eds. Kitchener, D.J & A. Suyanto), LIPI, pp. 23-29.

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

Tam, N.M., P.D. Tien & N.P. Tuan. 2002. Conservation of rodents in tropical forests of Vietnam. In: G.R. Singleton, L.A. Hinds, C.J. Krebs, & D.M. Spratt (eds.). *Rats, mice and people: Rodent biology and management*. Canberra: ACIAR, pp. 246-250.

Taman Nasional Lore Lindu. 2001. *Rencana Pengelolaan 2002-2027*. Volume satu: Data dan analisis. Taman nasional Lore Lindu-Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam-The nature Conservancy, pp. 1-205.

Wall, S.B.V. 2003. How rodents smell buried seeds: a model based on the behaviour of pesticides in soil. *Journal of Mammalogy* 84 (3): 1089-1099.

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