



Journal of  
**Plant Sciences**

ISSN 1816-4951



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## Research Article

# Diversity of Recorded Wild Mammals in Mount Tumpa Forest Park, North Sulawesi, Indonesia

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## Abstract

**Background and Objective:** Disturbance in Mt. Tumpa forest park, North Sulawesi has affected the diversity of its mammals species. This is caused by habitat degradation due to irresponsible land clearing and illegal logging which leads to forest habitat fragmentation. This threatens the survival of some Sulawesi's endemic mammals which reside in the forest, such as *Macaca nigra* and *Tarsius spectrum*. In this present study, survey was conducted to analyse wild mammals diversity record in forest park, North Sulawesi, Indonesia. **Materials and Methods:** Species richness, diversity and abundance of recorded mammals across the variety of habitat were estimated. This was done by establishing randomly selected transect lines across four types of habitat: primary and secondary rain forest, shrub, meadow and agricultural land. Species richness was the total number of the species in a community and measured using Margalef's index (Dmg). Shannon-Wiener (H') index was used to determine diversity of mammals. Evenness (E) of species distribution was calculated according to Krebs and supported by measurement of Lorenz curve using Excel 2013. **Results:** The data showed that there were a total of 621 individuals of mammals consist of eleven species and nine families recorded. The most abundant species was tarsier (*Tarsius spectrum*). The value of Shannon-Wiener index 1.48 indicates that the diversity, the spread of number of individuals in each species and community stability are moderate. While, the value of evenness below one (0.62) indicates that there is a dominant species in the community and the species distribution is uneven. In addition, the species richness in this area is moderate based on its value 1.71. Furthermore, the relatively low abundance (0.97) of macaque (*Macaca nigra*) indicates that the forest habitat has been degraded. **Conclusion:** The study reveals moderate diversity of wild mammals in Mt. Tumpa forest park. This information shows that hunting and deforestation in this area should be controlled for the sake of better conservation of the endemic and endangered faunal resource. The result of this study will contribute to the wild mammal conservation effort in this area, especially those of endemic species such as *M. nigra* and *T. spectrum*.

**Key words:** Crested black macaque, conservation, *Macaca nigra*, mammal survey, Mt. tumpa, species richness, *Tarsius spectrum*

**Received:** October 18, 2016

**Accepted:** November 25, 2016

**Published:** December 15, 2016

**Citation:** Vierta Ramlan Tallei, Saroyo and Trina Ekawati Tallei, 2017. Diversity of recorded wild mammals in mount tumpa forest park, North Sulawesi, Indonesia. J. Plant Sci., 12: 39-45.

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Indonesia has approximately 670 mammal species, more species than any other nation<sup>1</sup>. Mammals play an important role in wildlife as a counterweight in the ecosystem<sup>2</sup>. They occupy various tropic levels in the food chain, ranging from herbivorous mammals as predators of plants at the bottom, to the order of carnivorous mammals as top predators.

Sulawesi Islands, occupying about 53% of Wallacea region<sup>3</sup>, has a biodiversity of flora and fauna that are unique to the location, quite diverse and some are endemic. Among Wallacean fauna, at least there are 57.2% mammalian species, 40.5% bird species, 44.6% reptile species and 68.8% amphibian species, are endemic to the region<sup>3</sup>. Mount Tumpa forest park is a nature conservation located in the province of North Sulawesi. The park is located on the top of the mountain with an area of 208.81 ha and an altitude of 175- 627 m above sea level. There are 4 main ecosystem types in Mt. Tumpa forest park: primary and secondary rain forests, shrub, grassland and agricultural land<sup>4</sup>. The park is dominated by dry forest, which is inhabited by some mammals species endemic to Sulawesi. Topography of Mt. Tumpa forest park is hilly. The humidity is between 70 (in June) and 90% (in December). Average temperatures range from about 23-31 °C. The rain type is categorized as very wet with precipitation of 3.187 year<sup>-1</sup>. The vegetation is dominated by *Spathodea campanulata* and *Ficus* sp.<sup>4</sup>.

There are some concerns related to the survival of the mammals species in this park, for example forest habitat degradation due to irresponsible land clearing and illegal logging. Not to mention mammals wildlife poaching for consumption, illegal trading and pets<sup>4</sup>. All of these threaten the diversity of mammals. These activities can lead to species extinction or biodiversity erosion. This will in turn interfere with the forest community structure. The change in forest structure will significantly and considerably affect their taxonomic and phylogenetic components<sup>5</sup>, due to disappearance of some key structural components of the forest. The study on mammal species diversity is very important to do, because it can provide the basic data that can be used as one of the guidelines for the management of a conservation area. Initial survey on mammals in Mt. Tumpa forest park has been conducted by Tallei *et al.*<sup>4</sup>. The objective of this study was to estimate species richness, diversity and abundance of recorded mammals across the variety of habitat in this area.

## MATERIALS AND METHODS

**Study area:** Study of the diversity of mammals in Mt. Tumpa forest park was conducted from February-July, 2016. The

coordinate of the site is 43°38'19.39"N; 116°14'28.86"W, with an altitude of 175-627 m above sea level.

**Sampling of mammals:** Data of mammals were taken using line transect<sup>6-8</sup>. The observation was conducted in the morning and afternoon without and with the additional equipment, such as binoculars. Each species of mammals observed was recorded in accordance with the ability of visibility of the observer. The observer walked along the transect line and recorded any necessary data (direct and indirect encounters, such as footprints, hair, nest, trace of diet and stool). In line transect, the contact angle between the animals detected and observation line or observation angle was determined. The width of transect was 100 m, especially for the observation of *Macaca nigra*. Sampling repetition was conducted 3 times for every transect line. The mean length of each line was 5000 m. In addition, plots were made along the transect lines with the distance of each plot point is 1 km to observe and calculate the density of tarsier<sup>9</sup>. The limitation of this research lies in lack of equipment such as the availability of automated camera traps. The topology of the site is hilly and this situation makes it difficult to do research on a very steep area.

**Data analysis:** The following books were used for mammals identification: Biodiversity and conservation in North Sulawesi Indonesia<sup>10</sup>, Protected Mammals by Indonesian Legislation<sup>11</sup> and Identification Manual of Some Key Species in Sulawesi<sup>12</sup>. Indirect records such as fecal droppings, calls, track footprints, quills, holes, feeding signs were collected as indication of the existence of mammals<sup>13,14</sup>. Local people were also consulted for vernacular name, call and sign identifications.

**Population density calculation:** Estimation of population density of mammals by the line transect method was performed using Hayne's estimator (Dh) for density at specific location (h) as individual km<sup>-2</sup> according to Krebs<sup>15</sup>, as follow:

$$D_h = \frac{n}{2L} \times \left[ \left( \frac{1}{n} \right) \left( \sum \frac{1}{z_i} \right) \right]$$

Where:

Dh = Hayne estimator for density at location h (individual km<sup>-2</sup>)

n = Number of mammal

L = Length of transect (m)

z<sub>i</sub> = Sighting distance (m)

Density of tarsier was calculated using formula invented by Saroyo *et al.*<sup>9</sup>, where:

$$\text{Density} = \frac{\text{Number of duet calls} \times 4.01 \text{ individuals}}{\text{Plot wide}}$$

**Margalef's richness index:** Species richness shows the total number of the species in a community. Margalef's index (Dmg) was used as a simple measure of species richness<sup>16</sup>. The equation for determining the richness of species is as follow:

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

Where:

Dmg = Margalef's index

N = No. of all individual

S = No. of species

**Diversity index:** Diversity of mammals was determined using Diversity Index of Shannon-Wiener according to Krebs<sup>15</sup> with the following Eq.:

$$H' = \sum P_i \ln P_i$$

Where:

H' = Diversity index

P<sub>i</sub> = Proportion of individuals found in the i<sup>th</sup> species

ln = Natural logarithm

Generally, the H' index between 1-3 is considered as moderate species diversity. Diversity indices provide more information about community composition than simply species richness<sup>17</sup>. The idea of a diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities which is composed of discrete components<sup>18</sup>, such as species.

**Evenness index:** The Evenness (E) of the sample was calculated according to Krebs<sup>15</sup> with the following Eq.:

$$E = \frac{H'}{\ln S}$$

Where:

E = Constrained between 0 and 1.0

H' = Evenness assumes that all species are represented within the sample

Evenness index has a value range of 0-1. When there are similar proportions of all species, evenness approaches a value of 1.0. Determination of evenness index serves to determine

every mammalian species in a determined observation area. The actual diversity value (H<sub>s</sub>) can be compared to the maximum possible diversity (H<sub>max</sub>) by measuring the evenness<sup>19</sup>.

**Measurement of evenness using Lorenz curve:** The evenness also can be measured by Lorenz curve<sup>20</sup> which can be generated using Excel 2013. Lorenz curve was obtained by plotting cumulative proportion of species (X) against corresponding cumulative species relative abundance (Y)<sup>21</sup>.

## RESULTS

During the present study, a total of 621 individuals consisted of eleven species and nine families were recorded from Mt. Tumpa forest park (Table 1). Six species are considered as protected by Indonesian Government Regulation No. 7/1999, including *Ailurops ursinus*, *Strigocuscus celebensis*, *Tarsius spectrum*, *Macaca nigra*, *Sus celebensis* and *Rusa timorensis macassaricus*. Among these, *M. nigra* is considered as critically endangered by IUCN. The most commonly found families were *Phalangeridae* and *Muridae*. Their population density (D) and relative abundance, are listed in Table 2. The most dense species was *T. spectrum* (320 individuals km<sup>-2</sup>). The density of species ranged from 5-320 individuals km<sup>-2</sup>. Shannon-Wiener index (H') was 1.48. A community with Shannon-Wiener index (H') of 1.48 has an equivalent diversity as a community with 4.39 effective numbers of species (true diversity).

The species distribution in Mt. Tumpa forest park is uneven, with the E value of 0.62. This value was calculated according to Krebs<sup>15</sup>. Species evenness also measures the similarity in species relative abundance in a community<sup>15</sup>. The value 0.62 indicates that there is a dominant species in the community, namely *T. spectrum* which contributing 51.5% of the total population (Table 2). The result is supported by the Lorenz Curve for the evenness (blue line) (Fig. 1), which is far below the perfect equality. The Lorenz curve, which was generated using Excel 2013, indicates that the distribution number of species is not even in Mt. Tumpa forest park. Margalef's index was calculated as representatives of species richness index. The value of the index was 1.71, meaning that species richness in this area is moderate.

## DISCUSSION

The diversity of species, the spread of number of individuals in each species and community stability in Mt. Tumpa forest park are moderate. This is reflected by its value

Table 1: Recorded mammal species in Mt. Tumpa forest park

Species	Local name	Common name	Endemicity	CITES* appendix	IUCN**	Gov. Regulation No. 7/1999
<i>Ailurops ursinus</i>	Kuskus Beruang	Bear cuscus	Sulawesi and the Talaud Islands	No special status	Vulnerable	Protected
<i>Strigocuscus celebensis</i>	Kuskus Kerdil	Small cuscus	Strigocuscus celebensis	No special status	Vulnerable	Protected
<i>Tarsius spectrum</i>	Tangkasi	Spectral tarsier	Sulawesi, Peleng and Selayar islands	Appendix II	Vulnerable	Protected
<i>Macaca nigra</i>	Yaki	Sulawesi crested black macaque	Sulawesi and adjacent islands	Appendix II	Critically endangered	Protected
<i>Viverra zangalunga</i>	Musang	Malayan civet	-	No special status	Least concern	Not protected
<i>Macrogalidia musschenbroekii</i>	Musang Sulawesi	Sulawesi palm civet	Sulawesi	No special status	Vulnerable	Protected
<i>Rusa timorensis macassaricus</i>	Rusa	Timor deer	Sulawesi	Appendix I	Low risk/least concern	Protected
<i>Sus celebensis</i>	Babi Hutan	Sulawesi wild boar	-	No special status	Near threatened	Not protected
<i>Prosciurillus leucomus</i>	Bajing Kerdil Pucat	Sulawesi squirrel (Whitish dwarf squirrel)	Sulawesi	-	Data deficient	Not protected
<i>Paruromys dominator</i>	Tikus Biasa Sulawesi	Sulawesi giant rat	Sulawesi	-	Least concern	Not protected
<i>Lenomys meyeri</i>	Tikus Raksasa Sulawesi	Trefoil-toothed giant rat	Sulawesi	-	Least concern	Not protected

\*CITES: The convention on international trade in endangered species; \*\*IUCN: The international union for conservation of nature

1.48 for Shannon-Wiener index (H'). The H' value has an equivalent diversity as a community containing equally-common species of exp (H), namely the Effective Numbers of Species (ENS), which is the number of equally abundant species necessary to produce the observed value of diversity<sup>22,23</sup>. The effective number of species or true diversity in Mt. Tumpa is 4.39. The moderate diversity in this area was expected due to deforestation and animal hunting. Diversity index and evenness index values are maximized when all types of mammals are equally abundant. Diversity estimated reflects the true diversity of the delimited region.

The distribution of species in this area was uneven with the value of 0.62 and supported by Lorenz curve, which shows that the evenness is below the perfect line. The further away the Lorenz Curve is from the line of perfect equality (diagonal),

Table 2: Population density (D) and relative abundance (%)

Species	D (individual km <sup>-2</sup> )	Relative abundance (%)
<i>Ailurops ursinus</i>	20	3.22
<i>Strigocuscus celebensis</i>	5	0.81
<i>Tarsius spectrum</i>	320	51.50
<i>Macaca nigra</i>	6	0.97
<i>Viverra zangalunga</i>	5	0.81
<i>Macrogalidia musschenbroekii</i>	5	0.81
<i>Rusa timorensis macassaricus</i>	5	0.81
<i>Sus celebensis</i>	5	0.81
<i>Prosciurillus leucomus</i>	100	16.10
<i>Paruromys dominator</i>	100	16.10
<i>Lenomys meyeri</i>	50	8.05
Total individual	621	100.00

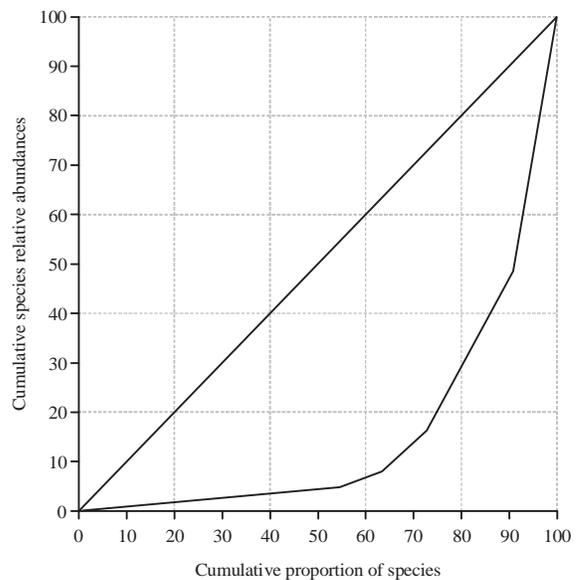


Fig. 1: Lorenz curve<sup>19</sup> for evenness distribution of mammals in Mt. Tumpa forest park. The diagonal line represents a perfect evenness

the more diverse is the sample and the more unevenly the values are spread out. This probably is due to the fragmentation of the forest park which leads to the changes in vegetation structure. Species distribution, abundance and composition are often influenced and modified if there is a disturbance in their natural habitats. This value is also influenced by the number of species present in a community and serves as a measure of the balance towards a community with each other. Evenness is also a measure of how similar the abundances of different species are. The high percentage of *T. spectrum* abundance contributes to the unevenness of the species distribution.

Margalef's richness index (species richness) is the simplest measure of biodiversity and is a count of the number of different species in a given area<sup>24</sup>. Based on Margalef's diversity index, mammalian species richness in this area is moderate, because the value is only 1.71. Species richness also refers to as alpha-diversity. Along with other factors, species richness is commonly used as a measure for determining the overall health of ecosystems. High species richness indicates a high level of stability in a given ecosystem<sup>25</sup>, thus allowing the ecosystem to better withstand natural or anthropogenic disturbance. It typically characterizes these ecosystems as healthy and robust.

The relative abundance of a species indicates how common or rare a species is relative to other species a given area or habitat type. Among the 11 species of mammals recorded, tarsier (*Tarsius spectrum*) was the most abundant species (contributing 51.5% or 320 individuals km<sup>-2</sup>). This number is higher than recorded tarsier's density in Mt. Klabat, North Minahasa Regency, with 204 individu km<sup>-2</sup> at 500m asl and 268 individu km<sup>-2</sup> at 1000m asl in this location<sup>26</sup> and 203 individuals km<sup>-2</sup> in Tangkoko Nature Reserve<sup>27</sup>.

The abundance of species in a habitat may be influenced by habitat suitability and also success in implementing adaptation strategies and high tolerance for interference. Fig trees (*Ficus* sp.) are abundance in this area and these trees are the sleeping sites of tarsier, resulted the high number of tarsier. Eventhough spectral tarsiers prefer secondary growth forests, because of high abundance of foods, they can be also found in primary rainforests. They feed exclusively on live animals such as moths, locusts, beetles and cicadas. Occasionally they eat small vertebrate (lizards or bats)<sup>28</sup>.

Sulawesi crested black macaque (*Macaca nigra*) is restricted to Northeast Sulawesi and its adjacent islands such as Manado Tua and Talise. Formerly, its population was found in Lembeh island, but most likely no longer exist in this island. Figs (*Ficus* spp.) are among their major diet, although they have a more diverse diet such as fruit of *Dracontomelon* spp.

and also invertebrates<sup>29-31</sup>. Their existence is critically endangered due to the habitat loss, which subsequently will give impact on reduction of the key components of their diets<sup>32,33</sup>. In Mt. Tumpa forest park, only 6 individuals km<sup>-2</sup> exist. As comparison, population density of this animal in Tangkoko Nature Reserve, North Sulawesi was 39.8 individuals km<sup>-2</sup> during 1999-2002, 51.4 individuals km<sup>-2</sup> during 2005-2011 and 61.5 individuals km<sup>-2</sup> in 2011 according to Kyes<sup>34</sup>. This larger number of individuals found in Tangkoko than in Mt. Tumpa is due to the bigger size of nature reserve in Tangkoko. Some authors argue that there is a relationship between the habitat quality and daily activities of *Macaca nigra*<sup>35</sup>. Their daily activities include feeding, foraging, moving, resting and social interaction. The change of their daily activities indicates the change in the habitat quality. In Tangkoko, their width of home range became larger and their day range became longer in order to gather foods due to habitat destruction. Daily activity of this animal has not been conducted in Mt. Tumpa.

No in depth investigation has been carried out on the diversity of mammals in this region, except initial survey conducted by Tallei *et al.*<sup>4</sup>. Therefore, the study that was conducted provides basic data for the conservation strategy of mammals in Mt. Tumpa Forest Park. After all, those mammals have important roles in maintaining the food chain, food web, nutrient cycle and the structure and function of an ecological system. In the forest ecosystems, primates can also be effective predictors of non-primate mammal community diversity<sup>36</sup>. Meanwhile, wild mammals hunting and deforestation are still happening in this area and it has to be controlled immediately for the conservation of the the endemic and endangered faunal resource. Conservation strategy can be conducted by various methods such as infusion of conservation material into local school curriculum<sup>37</sup>.

## CONCLUSION

It was concluded that the diversity and species richness of wild mammals in Mt. Tumpa are moderate. The distribution of species in the community is uneven. Researchers can be benefit from this study to propose conservation model in this area to prevent the decline of wild mammals diversity and number, given that this area is the home of some endemic species of Sulawesi.

## SIGNIFICANCE STATEMENT

This study discovers that the stability of mammals community and species richness in Mt. Tumpa forest park,

North Sulawesi are moderate and species distribution in the community is uneven. This study will help the researcher to propose the model for conservation in this area, thus contributing to the prevention of the declining of wild mammals.

### ACKNOWLEDGEMENT

This study was financed by The Support to the Development of Higher Education Project, Islamic Development Bank (IDB) 7in1, Sam Ratulangi University, through Penelitian Unggulan Perguruan Tinggi (University Competitive Research Grant No.026/SP2H/LT/DRPM/II/2016).

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