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Species diversity and population distribution of arboreal mammals in Kemuning Forest, Temanggung, Central Java, Indonesia

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Abstract. *Krisanti AA, Widiyani T, Imron MA. 2017. Species diversity and population distribution of arboreal mammals in Kemuning Forest, Temanggung, Central Java, Indonesia. Biodiversitas 18: 1190-1195.* Arboreal mammals which spent their life on the trees have significant roles for ecosystem balance and sustainability of forest ecosystem. This research aimed to reveal the diversity, population distribution, and the habitat used by arboreal mammals in Kemuning Forest of Bejen, Temanggung, Central Java, Indonesia. We conducted observation on the presence of arboreal mammals during four weeks started from April to July 2016. The observation was done within various times a day depends on the weather. 30 strips transect (ST) with 200m in length were established following the existing walking path for species identification. Point-quarter samplings (PQS) were used at every 50m of the track length for measuring diversity, density, and determining the dominant vegetation. There were 137 individuals of arboreal mammals detected and classified in 6 species, i.e., *Callosciurus notatus, Ratufa bicolor, Galeopterus variegatus, Macaca fascicularis, Trachypithecus auratus*, and *Nycteris javanica*. The largest population was *M. fascicularis* while the smallest was *G. variegatus*. There were 28 species of identified trees. Animals were observed in 22 tracks while the other six tracks were out of detected animals, so the relative frequency of animal was 80%. Diversity indices (H') of the animal were 1.342, whereas the vegetation diversity indices were 2.795. Dominant vegetation species were *Ficus macrophylla* (36%). The arboreal mammals were distributed in a clumped pattern. We concluded that Kemuning Forest had the potential to be the suitable habitat for arboreal mammals with better managements.

Keywords: Arboreal mammals, distribution, diversity, Java

INTRODUCTION

Mammals have the amounts of improved adaptation models among the other classes so they could endure more changeable environmental condition. Mammals have at least 5400 species dispersed in the entire earth surface with various body size, shape, appearance, and different function on the ecosystem (Hickman et al. 2011). Arboreal mammals spend almost their time doing various activities such as eating, socialization, and breeding, on the trees (Reed,1998). Mammals, both arboreal and terrestrial, are more often influenced by human activities than another animal classes. Human interferences mammals by hunting and domesticating for food sources, clothes, experimental objects, and so on (Hickman et al. 2011).

Forest is a natural habitat for various animal species, including arboreal mammals, and plants. Habitat is species specific concept which might be not fit the others. Forest habitat could be divided vertically into strata. Each stratum has its abilities to support the animals' life (Alikodra 2002), and it could be used to describe the habitat condition. For example, the percentage of arboreal mammals living on the upper stratum (forest canopy) could describe the condition of canopy and rainfall intensity on the a certain habitat (Reed 1998). The upper stratum composed such a complex habitat due to its supporting characteristics including elevation in which the vegetation is planted (Samaras and Youlatos 2010). Some species from the ordo of Primates, Carnivores, Hyracoideas, Pholidotes, Chiropters, and Rodents are arboreal mammals which are living in this upper stratum. Compared to another habitat type such as agroforestry area (Caudil et al. 2014), the forest has the highest percentage of the number of mammal species including the arboreals (Reed 1998). A habitat without massive disturbance supports inhabitant animal necessities like food, water, breeding sites, and shelters (Santosa et al. 2008).

Kemuning Forest is a productive land owned by its surrounding villages including Kemuning Village, Temanggung, Central Java, Indonesia. It has approximately 600 ha of a mixed forest. Center part of the forest is being kept natural by local people, while the border areas are used for residence area and coffee plantation area. In this small lowland forest, there are many flora and fauna species, some of them like *Trachypithecus auratus* and *Rhyticeros undulatus* are endemics in Java Island (IUCN 2016). From the issues of unawareness of the locals to biodiversity richness around them, we tried to collect as many information as possible, even from a single adaptation type of animal in small patch area, to renew the record, reveal some matters are going on, and also figure out solutions to those matters.

This study aimed to reveal the diversity and population distribution of arboreal mammal presence. Also, we tried to uncover the habitat used by arboreal mammals in Kemuning Forest, Temanggung, Central Java, Indonesia.

MATERIALS AND METHODS

This study was conducted in small patch area (± 230 ha) of Kemuning Forest, Bejen, Temanggung, Central Java, Indonesia (Figure 1). This area is located on the west side of Kemuning Village. It is under the authority of Indonesian State Forest Company (PERUM PERHUTANI) of Kedu Utara Unit Management. The survey was conducted for 28 days effectively, started from April to July 2016.

Survey method

The animal census was conducted in the tracks of 30 strip transects. Each track has a length of approximately 200 m, and 20 m length of belt to the right and left of the track. We assumed that every arboreal mammal on the tracks was observed. Although it was less of efficiency due to the discountable animals outside the track, we kept using a narrower belt (Williams et al. 2002) which was suitable to the area topography. The accuracy of visual estimation of the observation area is very important to prevent data bias. Transect pattern was determined randomly through a purposive sampling. The survey took time at the morning (06:00-10:00 a.m.), afternoon (11:00-16:00 p.m.), and in the evening (17:00-20:00 p.m.) (GMT +7). Point quarter samplings were applied to confirm the habitat use by arboreal mammals, the density of the trees, and diversity of the trees to find tree species dominance. On transect, we determined three stable points at every 50 m from the starting point, whether there is animal found or not.

Data analysis

Both animals and vegetations data were identified and analyzed statistically. From the animal data, we calculated diversity index, population estimation, distribution pattern, and frequency (Ludwig and Reynolds 1988; Bismark 2011). Tree density and dominance were calculated from the vegetation data (Zhu and Zhang 2009; Bismark 2011). Data normality was analyzed automatically by using Distance software (Thomas et al. 2010).

RESULTS AND DISCUSSION

There were 137 individuals of arboreal mammals observed during four months in Kemuning Forest. Those arboreal mammals are of 6 species, i.e. *Callosciurus notatus* (Plantain squirrel), *Macaca fascicularis* (Crab-eating macaque), *Ratufa bicolor* (Black giant squirrel), *Trachypithecus auratus* (Javan langur), *Nycteris javanica*

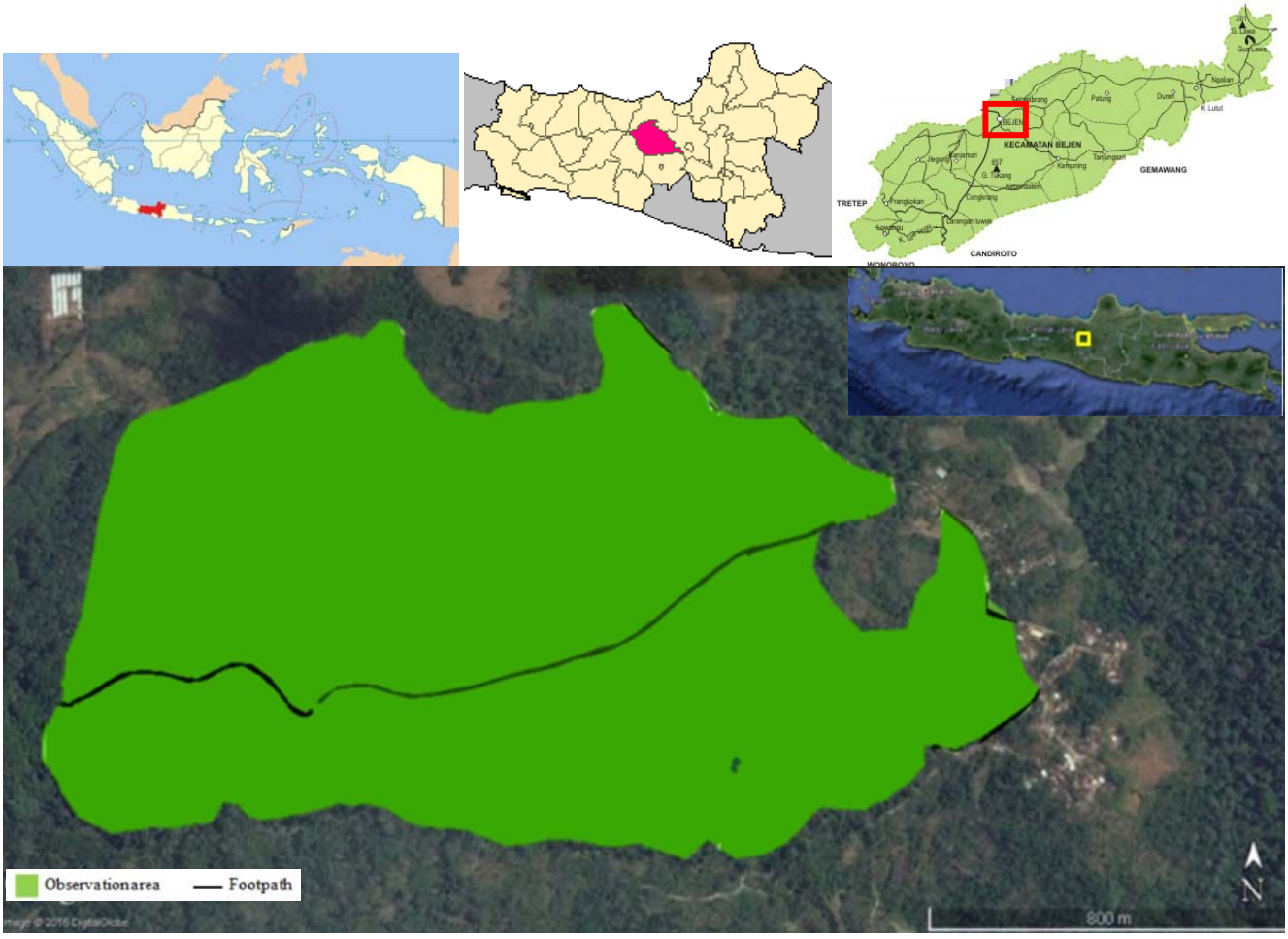

Figure 1. Observation sites of arboreal mammals in Kemuning Forest of Bejen, Temanggung, Central Java, Indonesia

(Javan slit-faced bat), and *Galeopterus variegatus* (Javan colugo). *C. notatus, M. fascicularis, R. bicolor,* and *T. auratus* which are the diurnal type, while *N. javanica* and *G. variegatus* are both nocturnal types (IUCN 2016). There were variation species in time, location, and population size (Figure 2). Huge populations were found on *M. fascicularis* with a total of 60 individuals observed. They lived in a group with around 15 to 35 members. *Macaca* group is led by a biggest and strongest (alpha) male. They were found on three different tracks at noon in the first, second, and third observation weeks. They were resting, socializing, and grooming in the tree branches when we found them.

The similar order to *M. fascicularis* is *T. auratus.* They live in a smaller group with 3 to 7 members. *T. auratus* were found after two weeks of observation. There were 12 individuals in 2 groups. They were resting in the tree branches. Because of their habitat is an open canopy as well as *M. facicularis,* they were noticed by aerial predators easily. A predator we found was *Spilornis cheela.* Open canopy habitat is a big threat to the population longevity, although they are agile and have a high capability in detecting other animal movements.

Callosciurus notatus and *N. javanica* are known to live in a smaller group than *M. fascicularis* and *T. auratus.* One to three individuals of *C. notatus* were usually observed along four weeks of observation on the tree branch or stem. *C. notatus* (34 ind.) were usually found in duration 6:00 a.m to 13:00 p.m. when they were gathering seeds or fruits and drinking water on the ground. Some of them could be seen in the afternoon (13:00-15:00 p.m.). The species were found on 22 different tracks. They are more easily found on different tracks than the other 5 species. Generally, *C. notatus* stays in the upper tree hollows near water source rather than in the bottom or fallen tree hollows.

Nycteris javanica acts more similar to the *C. notatus.* It stays in the upper tree hollows near the water source. 28 individuals of them were found at the second and fourth week of observation. This species is known to live in a small group with less than five members. They are probably nocturnal species; they become active after sundown until sunrise. Comparing to *C. notatus, N. javanica* is less tolerant to habitat disturbance due to its low adaptability (Duckworth et al. 2008). *N. javanica* liked a quiet forest (Hutson et al. 2008).

Solitary life was shown by *G. variegatus* and *R. bicolor* (Beatson 2011; Hayssen 2008). Both species were susceptible and intolerant to habitat disturbances, especially caused by humans. We found only a single individual of *G. variegatus* and 2 individuals of *R. bicolor*. *G. variegatus* was observed in the evening when it was sticking on the tree stem in the middle of a wind storm. Two individuals of *R. bicolor* were found only in a short time. According to the villagers, both species were undergone severe population decreasing in the past 16 years because of overhunting and trading were done by local people.

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The meeting points were different to each species due to internal and external factors. The internal factors are species' active time, species' daily habits, or population size, whereas external factors are weather condition and predator presence. *C. notatus* and *N. javanica* were widespread in many transect tracks, while *M. fascicularis, T. auratus, G. variegatus*, and *R. bicolor* were only found in one to three different tracks. Arboreal mammals were not identified on 6 of 30 tracks. These tracks were production forest area of *Pinus sp, Swietenia mahagoni*, and *Syzygium polyanthum.* These areas are regularly checked by the stakeholders, and their locations are closer

to the main road. These tracks are uncomfortable habitat because they have a very high intensity of disturbance due to the loud noises from vehicles or agricultural machinery and higher hunting risk. Relative frequency of arboreal mammals in the observation area of Kemuning Forest was 80%.

The diversity of arboreal mammals in Kemuning Forest was very low. Shanon-Weiner diversity index was 1.342. We indicated that some disturbance factors were causing less of arboreal mammals diversity on Kemuning Forest, such as the high intensity of anthropogenic activities and the low forest covering. In order to understand more about habitat condition on Kemuning Forest, we determined dispersion pattern horizontally. Arboreal mammals lived in clumped pattern. It means that they only lived in certain plots. There were some factors inhibited the distribution of the animals. The inhibitor factors should be studied more. However, we assumed briefly that the distribution of food and water resources are uneven, as well as the resting sites, heterogeneity of the habitat, natural behavior of the species, or any competition symbiosis.

Our observation area was a mixture of shade-coffee field and production forest. Tree canopies in such area were not as dense as the primary or secondary forest. There were more open areas which have high sunlight intensity on the day (Caudill et al. 2014). Vegetation density was 36.22% which was less than vegetation density of natural forest (Rahayu and Karyanto, 2015). Low forest coverage influenced arboreal mammals' life because tree vegetations are their substrate and their way of life. Agriculture system, which involved the human activities such as the use of agriculture machines, vehicles, and other engines, disturbs arboreal mammals' life as well as infrastructure development. Certain species could have a different response to habitat change or anthropogenic development. Species and population abundance were absolutely influenced either positively or negatively (Benitez-Lopez et al. 2010).

Through *PQS* we found 253 trees from 28 different species. Diversity index of vegetation was calculated as 2.795. Average vegetation density of the location was 0.0714 individuals/m^2 for trees with a diameter more than 10cm. Their canopies got full sunlight during the day. The big five species in common were *Pinus merkusii*, *Swietenia mahagoni*, *Sterculia* sp., *Ficus macrophylla*, and *Artocarpus elasticus* respectively. The dominant species was *Ficus macrophylla* with important value index of 36%. The diameter at breast height of *F. macrophylla* could reach more than 2m, and it was the biggest diameter in the observation area. This tree had big branches which diameter was more than 5 cm. Therefore, it was suitable for arboreal rodents like *C. notatus*. *Ficus macrophylla* produces sweet and sour small fruits with a diameter of about 1 cm and green to reddish orange in color. They are usually eaten by arboreal mammals even some birds. Some parts of *Schinus* sp., *A. elasticus*, and other tree species were also known as food sources or nest materials for arboreal mammals (see Table 1).

Data normality was tested by using Distance Software. It showed that between survey model and observation result was well matched (AIC_{min}= 145.80 and ΔAIC= 0). Calculation result (Table 2) was expected to be useful for the next study, such as habitat or species comparison and forest management.

Arboreal mammals in Kemuning Forest had many important natural roles in the ecosystem. For example, the arboreal rodent was as an indicator of the vegetation condition on a certain ecosystem. They are also useful for habitat regeneration through their 'catching habits' that is their way of bringing seeds or fruits to their nest or anywhere else make some of them to be left behind or dropped to the ground (Kumawat 2013). Microchiroptera bats could control the insect pest population effectively (Prakarsa 2011). Based on our discussion with local people, we knew that arboreal mammals became one of the hunters' favorite hunting objects, -as well as birds and

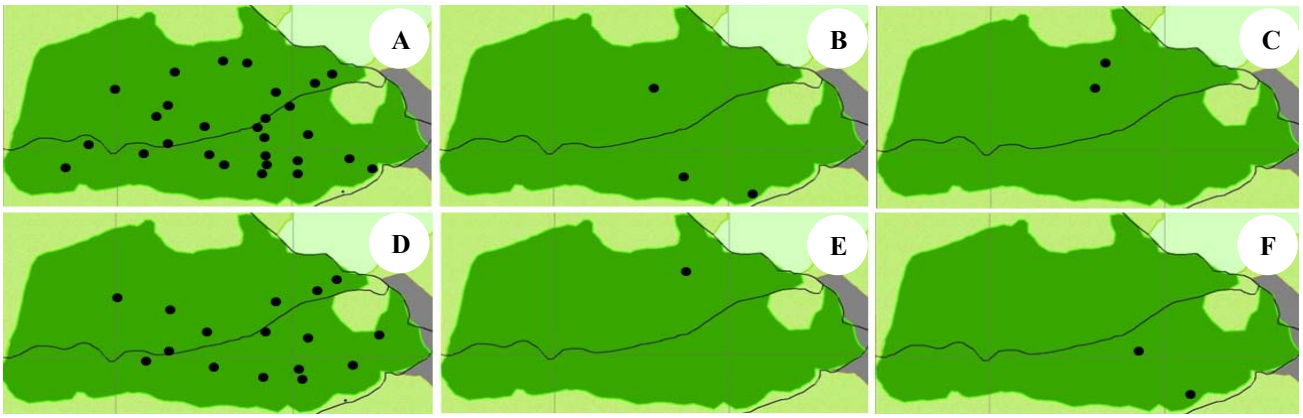

Figure 2. Arboreal mammals distribution in Kemuning forest of Bejen, Temanggung, Central Java, Indonesia. Black dots indicate animal location found. A. *Callosciurus notatus*, B. *Macaca fascicularis*, C. *Trachypithecus auratus*, D. *Nycteris javanica*, E. *Galeopterus variegatus*, F. *Ratufa bicolor*

Tabel 1. The use of parts of trees by arboreal mammals in Kemuning Forest of Bejen, Temanggung, Central Java, Indonesia

Use	Animal species	Tree species	Parts of tree
Food source	*Callosciurus notatus*	*Artocarpus elasticus*	Fruits
		Ficus macrophylla	Fruits
		Ficus racemosa	Fruits
		Mallotus japonicus	Fruits
		Pinus merkusii	Fruits
		Syzygium aqueum	Fruits
	Macaca fascicularis	*Artocarpus elasticus*	Fruits, flowers
		Ficus racemosa	Fruits
		Musa paradisiaca	Fruits
		Syzygium aqueum	Fruits
	Trachypithecus auratus	*Ficus macrophylla*	Fruits, leaves
		Ficus racemosa	Fruits, leaves
		Musa paradisiaca	Fruits
		Syzygium aqueum	Fruits, leaves
		Schinus sp.	Leaves
	Nycteris javanica	*Mallotus japonicus*	Fruits
		Syzygium aqueum	Fruits
	Galeopterus variegatus	*Syzygium polyanthum*	Young leaves
Resting site	*Callosciurus notatus*	*Albizia chinensis*	Stem, branches
		Ficus macrophylla	Stem, branches
		Swietenia mahagoni	Stem
		Schleichera oleosa	Stem, branches
		Ganophyllum falcatum	Stem, branches
		Afzelia javanica	Stem, branches
		Schinus sp.	Stem, branches
	Macaca fascicularis	*Ficus macrophylla*	Stem, branches
		Sterculia sp.	Stem, branches
	Trachypithecus auratus	*Ficus macrophylla*	Stem, branches
	Nycteris javanica	*Bambusa* sp.	Branches
		Bombax ceiba	Branches
		Hibiscus macrophyllus	Branches
		Sterculia sp.	Branches
	Galeopterus variegatus	*Syzygium polyanthum*	Stem
	Ratufa bicolor	*Swietenia mahagoni*	Stem
		Sterculia sp.	Stem

Table 2. Calculation result of arboreal mammals study in Kemuning Forest of Bejen, Temanggung, Central Java, Indonesia

Obj.	Σ tracks	Analysis	
		Parameter	Result
Arboreal Mammals	22	Index of diversity (H')	1,34287 *(low)*
		Biggest population estimation (P)	*M. fascicularis* (575 ind.)
		Distribution pattern	Clumped
		Animal Frequency (FR)	80%
Vegetation (Trees)	90 points (3 points/ track)	Index of diversity (H')	2,79506 *(moderate)*
		Index of Important Value (INP)	36% *(F. macrophylla)*
		Density (D)	0,071411 ind/m^2

terrestrial animals. It was because arboreal mammals like *R. bicolor*, *G. variegatus*, and unseen species of *Nycticebus javanica* had exotic appearances. Nowadays, developments of infrastructures for civilization and agriculture industry are decreasing the forest area, and it also means that the natural forest ecosystem changes too. Some arboreal mammals such as *C. notatus* and *M. fascicularis* are tolerant to the habitat changes due to their fast and limitless reproduction over the years. The others are intolerant to the habitat change even though in the less destruction habitat.

These kinds of species are susceptible. They are some endemic species such as *T. auratus* and *N. javanica* that should be more protected.

To conclude, Kemuning Forest has a low arboreal mammals presence. A total of 137 individuals were found. They belong to 6 species, i.e. *C. notatus*, *M. fascicularis*, *T. auratus*, *N. javanica*, *G. variegatus*, and *R. bicolor*. *M. fascicularis* population was the largest species due to their social life. They lived in a bigger group. *C. notatus* was detected easily in almost all tracks (30 tracks), while *G. variegatus* and *R. bicolor* were hardly found. These arboreal mammals were distributed in a clumped pattern. There were some inhibitor factors which cause the animals to inhabit only on a certain area. Coffee-shaded area in combination with production forest could not give more life support for those animals on the observation area, yet it sheltered them quite well from natural phenomena and predators. On this small patch, there were *F. macrophylla* which had the biggest diameter (reaching >2 m). It covered some parts of the area, even though, the resting sites and food sources for the arboreal mammals are abundances. Animal hunting is done by local people from the outside villages still existed and acted almost in every day. The conservationists should put more attention this matter. This case happens in Kemuning Forest and other areas. Continuous research on arboreal mammals and their habitat in Indonesia forest are essential. Arboreal mammals are very important and useful for forest regeneration. It is important to reveal the inhibitory factors on the arboreal mammal's life inside the forest. It helps stakeholders arranging the best management for mammals or the whole forest conservation strategies.

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