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Density of spectral tarsier (*Tarsius spectrum*) in agricultural land, mangrove, and bush habitats in North Sulawesi, Indonesia

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Spectral tarsier (*Tarsius spectrum*) is an endemic Sulawesi primate species. This animal is one of the smallest primates and an endangered and protected species. A study about the density of spectral tarsier in agricultural land, mangrove, and bush habitats in North Sulawesi has been conducted. This research aimed at analyzing the density of spectral tarsier outside the forest areas. Method used in population survey was circular plots with a radius of 100 m of each plot which were placed systematically. Density is based on a duet vocalizations. This analysis revealed that the highest density of spectral tarsier was in agricultural land (mean population density = 161.0 individuals/km²). The lowest density was in shrub (mean population density = 40.1 individuals/km²). The mean population density of this species in mangrove was 134.4 individuals/km². Statistical analysis indicated that there were significant difference ($p = 0.000000$) of density of spectral tarsier among the three habitats. Subsequent test using post-hoc Tukey HSD test showed that the population density of spectral tarsier in agricultural land was significantly different ($p = 0.000022$) from those in bush. There were significant difference ($p = 0.000022$) between spectral tarsier population density in mangrove and bush. However, there was no significant difference ($p = 0.203754$) between the population in agricultural land and mangrove. While comparing with the population density of spectral tarsier inside forest area (the data gathered from other researches), the population density in outside forest areas as mentioned above was lower. This research showed that there were significant difference of density of spectral tarsier among the three habitats. Those area of studies are prone to threats due to irresponsible activities conducted by surrounding community such as land clearing and tree logging.

.Keywords: Agricultural land, mangrove, bush, density, population, spectral tarsier, *Tarsius spectrum*, tangkasi

INTRODUCTION

Spectral tarsier (*Tarsius spectrum*, synonym with *Tarsier tarsier*) with the local name tangkasi, is a primate endemic to Sulawesi subregion. This species is distributed in Sulawesi main land and other satellite islands. In North Sulawesi, they are found in Minahasa peninsula, Lembeh island, Talise island, and Manado Tua island. This species is one of several other *Tarsius* species in Sulawesi. Until recently, there are several

identified species of Tarsier: *T. spectrum*, *Tarsius sangiriensis*, *Tarsius pumilus*, *Tarsius dentatus*, *Tarsius pelengensis*, *Tarsius larian*, and *Tarsius tumpara* (Shekelle, 2008; Merker and Grove, 2006; Shekelle et al. 2008). Spectral tarsier is protected by Indonesian Law No 7/1999. This species is also under Appendix II CITES, and considered as vulnerable by IUCN (Shekelle and Salim 2008).

In North Sulawesi main land, they are found

ranging from the seashore to a height of 1,500m above sea level (Saroyo and Koneri, 2013; Mantouw et al. 2015). Saroyo and Koneri (2013) stated that beside found in primary rainforest, this species can be found in habitats other than forest, such as agricultural land, bush, and mangrove. In the forest area, they occupy a nest used to shelter them from the heat of sun and other environmental factors, and also avoiding the reach of predators (Saroyo, 2008). As nesting places, they use banyan tree cavity, other dead tree holes, dead branches on a tree, a tangle of lianas, a grove of bamboo (*Bambusa* sp.), and sugar palm (*Arenga pinnata*) trees. Outside of forest area, they make use of bamboo groves, clumps of Pandanus (*Pandanus* sp.), in the room between the ground and litter, and in holes in the ground (Saroyo, 2008).

The distribution of spectral tarsier is not limited only to inside forest areas, but also outside of the forest area. Conservation strategies are applied not only by considering the population in the forest, but also on several other habitat types, especially agricultural lands, bushes, and mangroves. Threats to the survival of the species outside the forest area is much greater than in the forest, mainly by human activities and ecosystem instability. Therefore, this research was aimed at analyzing the density of spectral tarsier (*Tarsius spectrum*) outside the forest area.

MATERIALS AND METHODS

The research was conducted in January to October 2013 in three spectral tarsier habitat types, namely agricultural areas, mangrove, and shrubs. These habitats are located outside the conservation area in Bitung, North Sulawesi, Indonesia, namely outsides of Tangkoko-Batuangus Nature Reserve (BTNR), Dua Sudara Nature Reserve (DSNR), and Batuputih Nature Park (BNP). Survey on spectral tarsier density was conducted using methods developed by Saroyo et al. (2014). In this method, plot areas were used as sampling points with diameter of 200 m in each habitat. This method is based on the use of vocalization given the difficulty of using line transect method because of the small size of the animals and they are nocturnal. Vocalization produced by a mated pair of adults before sunrise is called the duet call. This duet call is sounded on the way back to their nests after browsing during the night in the forest. Each duet call represents one monogamous group (a family). The formula for measuring the density of population is number

of duet call multiplied by 4.01 and then divided by the total of observation area (Saroyo et al. 2014). Sampling was conducted using the paths specified in each of the three types of habitat. The distance between the lines on the farm and bush habitats was 500m, while in the mangrove habitat only one lane was used, given the thin habitat of mangrove. The distance between one plot to the next plot was 300 m. The number of sampling plots in agricultural land, bush, and mangrove were 100, 53, and 76, respectively. One-way ANOVA was used to analyse the population density differences among the three habitat types using STATISTICA 6.0. Vegetation characteristics of those habitat were also recorded.

RESULTS

Agricultural land is analogous to a secondary forest. This habitat was composed of the following vegetation: coconut (*Cocos nucifera*), sugar palm (*Arenga pinnata*), cananga tree (*Cananga odorata*), bamboo (*Bambusa*, *Gigantochloa*), New Guinea walnut (*Dracontomelon dao*), gutta tree (*Palaquium amboinense*), ranggu (*Koordersiodendron pinnatum*), spiked pepper (*Piper aduncum*), African tulip tree (*Spathodea campanulata*), macaranga (*Macaranga* spp.), screw pine (*Pandanus* spp.), cempaka (*Elmerillia tsiampaca*), jackfruit (*Artocarpus altilis*), pangi/keluak (*Pangium edule*), banana (*Musa* sp.), bandicoot berry (*Leea* sp.), coral tree (*Erythrina* sp.), mahogany (*Swietenia macrophylla*), New Guinea rosewood (*Pterocarpus indicus*), teak (*Tectona grandis*), milkwood (*Alstonia* sp.), matoa (*Pometia pinnata*), gnemon (*Gnetum gnemon*), great morinda (*Morinda citrifolia*), and Indian Beech tree (*Pongamia pinnata*). Mangrove habitat was composed of the following vegetations: grey mangrove (*Avicennia marina*), powder-puff tree (*Barringtonia racemosa*), nipa palm (*Nypa fruticans*), sago palm (*Metroxylon sagu*), canary wood or yellow wood (*Nauclea orientalis*). Bush habitat was composed of the following vegetation: bonesets (*Eupatorium odoratum*), wild-sage (*Lantana camara*), yam (*Dioscorea hispida*), as well as seedlings of spiked pepper (*Piper aduncum*), African tulip tree (*Spathodea campanulata*), wild sugarcane (*Saccharum spontaneum*), and chinaberry tree (*Melia azedarach*). The population density of spectral tarsier in three habitats is shown in Table 1. The average population density of spectral tarsier in agricultural land, mangrove, and bush were 161.0, 134.4, and 40.1 individuals/km², respectively.

Table 1. Population density of spectral tarsier in agricultural land, mangrove, and bush.

Type of habitat	Number of plots	Mean of Density (individual/km ²)
Agricultural land (analogous to a secondary forest)	100	161.0
Mangrove	76	134.4
Bush	53	40.1

One-way ANOVA statistic result showed that there was no significant differences ($p = 0.000000$) in population density among the three habitats. Further analysis using Tukey HSD test showed that the population density of spectral tarsier in agricultural land was significantly different ($p = 0.000022$) from those in bush. There were significant difference ($p = 0.000022$) between population density in mangrove and bush. However, there was no significant difference ($p = 0.203754$) between the population in agricultural land and mangrove.

DISCUSSION

Spectral tarsier research was mainly focused inside the forest area. Saroyo et al. (2014) found that in Tangkoko Batu Angus Nature Reserve (TBNR), the population density of spectral tarsier was 1.89 individuals/ha or 189 individuals/km². When compared with the results of previous surveys, the density of spectral tarsier tangkasi in TBNR tended to increase. Estimated population density of this species in TBNR was 70 individuals/km² in 1980 (MacKinnon and MacKinnon 1980), 156 individuals/km² in 1997 (Gursky 1998a), 189.0 individuals/km² in 2013 (Saroyo et al. 2014), and 203 individuals/km² in 2015 (Lumante et al. 2015). This result is certainly contrary to the general assumption that wild animals in North Sulawesi experienced a population decline. This is because the study site is a place of execution of various research activities and tourism, although according to the legislation, tourism activities are not allowed in the nature reserve. In fact, this event which was originally held in the Batuputih Natural Park (BNP) has also happened in TBNR, which is located next to BNP. With so many activities going on TBNR, then the hunting will be low. This species is also not a hunting target for consumption because of its small size and is nocturnal.

Based on survey on 57 nests (groups), the average of group size per nest was 4.01 ± 1.83 with the mode 4. The average group size of *T. tarsier* was 3.1 individuals (mode 2) (Gursky,

2000). Saroyo (2008) reported that average group size inside TBNR was 4 ± 2.45 individuals (mode 3). This means there has been an increase in the number of individuals of spectral tarsier per group.

Agricultural land is the most supportive habitat for spectral tarsier life because it has characteristics similar to secondary forest. Some place of this kind of habitat were planted with coconut tree. Other plants also grow here in any stage of growth thus forming structures such as secondary forest vegetation. This type of habitat is very good in supporting the tarsier population because it provides a variety of resources needed, especially feeding, nesting, and daily activities. Secondary forest provides many kind of insects which are the main food of the tarsier. Report of Saroyo (2008) which is supported by field observation, spectral tarsier uses several type of trees for their nesting sites. These plants were *Arenga pinnata*, *Bambusa* sp., *Gigantochloa* sp., and *Pandanus* sp. The denser vegetation was mainly composed of trees thus providing means for this animal in their daily exploration in accordance with their type of animal locomotion, namely vertical leap and cling.

Spectral tarsier is nocturnal or active during night time. In the afternoon after dark, the family goes out of the hive and perform daily activities. Research on their activities in the cage were feeding (1.5%), foraging (8.5%), moving (26.8%), resting (57.5%), and social (5.5%) (Manori et al. 2014). After doing their activities overnight, spectral tarsier family will return to the nest in the morning. At that moment, the paired tarsier will sound a duet call.

Threats to the survival of spectral tarsier in agricultural areas in North Sulawesi are from land clearing by using chemical herbicides and plant burning. The methods of clearing land like this often eliminates the entire vegetation thus affecting the availability of insect in these habitats. Spectral tarsier feed exclusively on live animals such as moths, locusts, beetles, spiders and cicadas. Occasionally they eat small vertebrate (lizards or bats) (Gursky, 2000; Wirdateti and

Dahrudin, 2006). In captivity in cages, they also consume beef, rat meat, and fish (Kiroh, 2009).

Mangrove is a quite good habitat in its carrying capacity to the tarsier population. Although mangrove vegetation is less diverse, land clearing effect is so small that tarsier can live with just a little disturbance from human activities. This habitat also provides the main source of tarsier's diet due to the abundance of insects. Threats to this habitat come from the surrounding communities who use mangrove wood for domestic. In the mangrove habitat, tarsier uses *Nypa fruticans* and *Metroxylon sago* as nesting sites.

The worse situation happened in bush. This habitat type is very fragile because of flammable and farmers usually clear it by burning and herbicide spraying. Carrying capacity of this habitat for tarsier population is lower compared to agricultural habitat due to the lack of trees through which tarsier moves during daily activities. Spectral tarsier often uses the space formed between litter and soil, which although can protect them from sun exposure, but give less protection against predators, especially snake and *Varanus salvator*. The main predator of this species in TBNR is snake (Gursky, 2005).

Compared to forest, population density in agricultural land, mangrove, and bush are lower. These results indicate that the forest is still the main spectral tarsier habitat although they also can be found outside the forest habitat. Research on density of tarsier in bush and mangrove habitats in the area directly adjacent to the forest showed a higher number (Polii et al. 2015). This is because these locations are the area of invasion or migration of tarsier from the forest. Forest in conservation area such as TBNR, Klabat Forest Protection, Mount Tumpa Forest Park, and other conservation areas can become stocks of spectral tarsier. These areas are relatively protected from human activities. As an addition, spectral tarsier is not a hunting target for consumption thus number of hunting activities for this species is low. This primate is known to highly protect their territories. Its main social structure is monogamous family consisted of adult male, adult female, and juveniles (Gursky, 1998b). When the juveniles are grown, they will come out of the group and form new groups with their partner. Given that each group will protect their territories, thus if a newly formed group cannot compete to obtain their territory, they will have to go out of the location and find a new territory outside the forest. Therefore, population density of tarsier in border

or adjacent to protected areas is high.

CONCLUSION

This study revealed that the highest density of spectral tarsier was in agricultural land (mean population density = 161.0 individuals/km²). The lowest density was in shrub (mean population density = 40.1 individuals/km²). The mean population density of this species in mangrove was 134.4 individuals/km². There were significant difference of density of spectral tarsier among the three habitats.

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed to the research and manuscript preparation. S performed the research in the field. RK did the data analysis. S, TET, and RK prepared the manuscript and its revision. All authors read and approved the final version.

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