Population of Proboscis Monkey (*Nasalis lavatus*) in Manggar River, Balikpapan City, Indonesia

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Abstract. A population estimation of proboscis monkeys (*Nasalis larvatus*) has been conducted in Manggar River, Balikpapan. In this non-conservation area, the anthropogenic activities threaten the proboscis monkey habitat. Boat survey technique was applied along ± 17 km of the river in the morning and evening. The number of proboscis monkeys in the surveyed area was estimated to range from 57 to 69 individuals with estimated population density of 4.75 individuals/Km². Moreover, the population of this primates was divided into 4 groups and the sex ratio between adult males and females was 1:2.33. The proboscis monkeys were distributed in the middle of the river to the upstream. The highest population was found in the upstream area with less human activities. Conservation efforts in the Manggar River need to be carried out considering the proboscis monkey habitat in the area has been fragmented and isolated. These efforts could involve local economic communities.

1. Introduction
Proboscis monkey (*Nasalis larvatus*) is one of the endemic primates of the island of Borneo with a declining global population. This species is categorized as “Endangered Species” on the IUCN Red List and is prohibited from being traded internationally on the CITES Appendix I [1,2]. Its unique habitat is always strongly associated with the presence of water, e.g. mangrove, peat swamp, and riparian forests [1,3–5]. Currently, proboscis monkey habitats coincides with the areas managed by human e.g. ponds, plantations, and settlements. In fact, the proboscis monkey population is more widely known to be outside of the conservation areas.

Most of the information on proboscis monkey in Balikpapan was collected from Balikpapan Bay area, which has a vast mangrove forest [6,7]. Yet, there hasn't been any report on the population size and distribution of this primate in Manggar River. Manggar River is a mangrove forest on the east coast of Balikpapan. The 20-km-length river is a non-conservation area and also a habitat for proboscis monkeys [8]. Collecting data on the population is needed for proboscis monkey conservation in Manggar River.

In general, the proboscis monkey population in the Manggar River has been isolated and fragmented [8]. This area is no longer connected with other proboscis monkey populations around Balikpapan. Land conversion (e.g. settlements, plantations, and ponds) is the main factor that threatens the mangrove forest in this area [6]. It also contributes to the decreasing of the habitat suitability for proboscis monkeys [3,9]. In long term, it increases the level of vulnerability to local
extinction of proboscis monkey [7,10]. On the contrary, some studies reported that fragmented habitats can still support proboscis monkey population, such as in the Sungai Hitam, Samboja [11]. This provides information on the response of the proboscis monkey population to habitat changes [5–7,12]. In addition, information related to human population around the habitat is also useful for sustainable environmental management, e.g. ecotourism development.

This study aims to analyse the population of the proboscis monkey population along the Manggar River, Balikpapan City. The results of this study could suggest some efforts in proboscis monkey conservation in the non-conservation area. In addition, this information can also be used for sustainable environmental management.

2. Materials and methods

2.1. Study site
Survey was conducted along the Manggar River with a cumulative distance of 17 km on November 2020 (Figure 1). The dominant vegetation at the riverbank are mangrove vegetation. We started from the estuary (bordering the Makassar Strait) to the upstream area (bordering the Manggar reservoir). Settlements have been built in the downstream, while ponds and plantations dominated the area from the middle to upstream.

![Figure 1. Map of research site.](image)

2.2. Procedure
Boat survey technique was used in this study with a census approach [12]. This technique allowed direct observation at the riverbank using a boat. Yet, in certain condition when a definite validation is required, a census will be carried out on foot [5]. The survey was conducted in two session per day; in the morning and in the afternoon. In the morning the observation started at 6.30 to 10.00 AM while in the afternoon at 15.30 to 18.00 PM. Each individual in each group was counted and classified by age and sex. At least three replicates were conducted to ensure the number of proboscis monkeys in each group. Additional information was also collected, e.g. the vegetation community as food sources.

2.3. Data analysis
The data analysis was carried out descriptively on the number of individuals per group, sex, and age class. The population proboscis monkey was calculated based on the number of individuals in each replication. We extrapolated the correction factor using the variation in the number of individuals based on the formula of Bismark and Iskandar (2002) [13]. The correction factor becomes a multiplier factor for predicting the maximum number of individual sighted. Furthermore, the proboscis monkey
population data was presented through tabulation, descriptively. The density of proboscis monkeys was calculated by the formula from Laman and Aziz [5] as per below:

\[
\text{Population density} = \frac{\text{Cumulative number of individual sighted}}{\text{Total surveyed area (sq Km)}}
\]  

(1)

Where:
- Population density: Ind/Km\(^2\)
- Total surveyed area: Cumulative distance of surveyed riverbank (Km) x 0.75 Km

3. Result

Four groups of proboscis monkeys were sighted during the observation. The range of the total number of individual sighted is from 57 to 69. The estimated density population is 4.75 individuals/Km\(^2\). Data on the estimated population of proboscis monkeys and their age are shown in Table 1.

**Table 1. Proboscis monkey population in Manggar River.**

| No | Id. Group | Number of individuals | Age class | Vegetation around finding area |
|----|-----------|-----------------------|-----------|--------------------------------|
| 1  | A         | 11                    | Adult male: 3 | *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina*, *Aegiceras cornulatum*, *Vitex pinnata*, *Hevea brasiliensis* |
|    |           |                       | Adult female: 5 |
|    |           |                       | Sub adult: 3   |
|    |           |                       | Juvenile: -    |
|    |           |                       | Infant: -      |
| 2  | B         | 13                    | Adult male: 1  | *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina*, *Nypa fruticans*, *Xylocarpus granatum*, *Lumnitzera littorea*, *Acrostichum speciosum*, *Dillenia suffruticosa*, *Hevea brasiliensis* |
|    |           |                       | Adult female: 4 |
|    |           |                       | Sub adult:     |
|    |           |                       | Juvenile: 7    |
|    |           |                       | Infant: 1      |
| 3  | C         | 10                    | Adult male: 3  | *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina*, *Xylocarpus granatum*, *Nypa fruticans* |
|    |           |                       | Adult female: 5 |
|    |           |                       | Sub adult: 2   |
|    |           |                       | Juvenile: -    |
|    |           |                       | Infant: -      |
| 4  | D         | 23                    | Adult male: 2  | *Nypa fruticans*, *Lumnitzera littorea*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Heritiera sp.*, *Vitex pinnata*, *Acrostichum speciosum*, *Exoecaria agallocha* |
|    |           |                       | Adult female: 7 |
|    |           |                       | Juvenile: 12   |
|    |           |                       | Infant: 2      |

Correction factor 1.21
Min amount 57
Max amount 69
Remark: *) = Eaten by Proboscis monkey

4. Discussion

Stark et al. (2012) found 1,400 individuals of proboscis monkeys in Balikpapan Bay [7], while Atmoko et al. (2017) reported 143 individuals in the Sungai Hitam Samboja [11]. Both locations are relatively close to the Manggar River, but the proboscis monkey habitats are no longer connected. Compared to the population in both areas, the proboscis monkey population in the Manggar River is much smaller. Thus, the proboscis monkeys in the Manggar River is estimated to be the last remaining population on the East coast of Balikpapan City. To our knowledge, this is the first study on proboscis monkey population in the Manggar River. Therefore, the trend of the proboscis monkey population from time to time is unknown. This survey result could be used as an initial reference for other studies or for constructing a conservation plan.
The density of the population in the Manggar River (4.75 individuals/km²) is lower than the density in the Berau Delta (6.65 individuals/km²) [14] and Tapin, South Kalimantan (28.34 individuals/km²). Yet, it is higher than proboscis monkey population in Sarawak (0.96–2.76 individuals/km²) [5]. These differences are because of the characteristics of the distribution and habitat quality. Low population density occurs in the area with high anthropogenic pressure and a small remaining habitat. It is in line with Bernard et al. (2021) that the damaged riverine habitat has a significant impact on decreasing proboscis monkeys’ density [15]. From this statement and the results of the study, it can be concluded that human activities in Manggar River affected the existence of proboscis monkeys.

The distribution of the proboscis monkeys increases towards the upstream of the Manggar River. Proboscis monkeys were more common to be sighted in the midstream and upstream with less human activity. Besides, the groups with the highest populations were found in the most upstream areas. We assumed that the level of human disturbance caused this phenomenon. This behavior is understandable because of its tendency to be timid and avoid humans [10,16]. The river estuary area has more settlements. Also, land conversion encourages proboscis monkeys to search for more suitable habitats. Currently, it is estimated that the remaining mangrove forest in the Manggar River is 286.86 Ha [8] (Figure 2). The existence of mangrove and riparian forests also plays an important role as a source of food as well as sleeping trees. Midstream and upstream areas provide a place for proboscis monkeys as feeding ground. Both areas are still connected to secondary forest fragments and community plantations. It is common for proboscis monkey to feed not only on mangrove vegetation, but also terrestrial vegetation [17–19].

![Figure 2. The remaining mangrove forest as proboscis monkey habitat in the Manggar River (Photo taken by Frans Paginta).](image)

Adult female and juveniles dominated the population in the Manggar River. Meanwhile, the percentage of children and infants was 8% and 6% of the total population, respectively. This shows that the proboscis monkey population in the Manggar River area continues to reproduce. But, we considered the process to be at a low level because we found only 3 infants during the observation. On the other hand, the infant itself is an age group that is prone to death due to predators or other natural causes [10,16]. Although, low number of juveniles and infants is not an indicator of a decline
in natality. This requires more study to develop time-series data. From the data, we can conclude the dynamic of the proboscis monkey population. On the other hand, there are many factors that affect the reproduction of the primates. The food resources is one factor that determines female reproduction in polygynous species such as proboscis monkeys [20].

The level of sex ratio between individual adult males and adult females is 1: 2.33. This sex ratio level is lower than the sex ratio in Delta Berau (1: 5.6-1:6.1) [14] and in Tapin, South Kalimantan (1:3.3) [4]. Sex ratio is a significant influence on the successful reproduction of proboscis monkey. The sex ratio of adults in their productive years can predict the effective population. Proboscis monkeys live in a group with one alpha male and several adult females. The high number of adult females will be more advantageous in reproduction. Adult males can maximize access to fertile female individuals to produce offspring (Figure 3).

![Figure 3. One of adult male (Photo taken by Mardi T. Rengku).](image)

Several plants used as food sources for the proboscis monkey were observed in the Manggar River, e.g. *Rhizophora mucronata*, *Avicennia marina*, *Vitex pinnata*, and *Hevea brasiliensis*. Some of them were also reported to be a food source in other habitats, e.g. *Sonneratia alba*, *Sonneratia caseolaris*, *Rhizophora apiculata*, *Xylocarpus granatum*, *Acrostichum aureum*, *Dillenia suffruticosa*, *Bruguiera spp.*, *Artocarpus spp.*, etc [17–19]. *Vitex pinnata* and *Hevea brasiliensis* are terrestrial vegetation that forms a community behind the mangrove forest. Local people plant *Hevea brasiliensis* (rubber tree) in the surrounding area. Though, proboscis monkeys are still able to adapt and breed in the plantation areas [19]. We assumed that the type of proboscis monkey feed in the Manggar River is more than the data described in this study.

The common challenge for proboscis monkey conservation is that more population occupies non-conservation areas. Currently, the level of habitat suitability in Kalimantan is estimated to be only 5% left with 2% of habitat loss per year [9,16]. Therefore, conservation efforts in the Manggar River need to be carried out through an approach that also accommodates socio-economic aspects. The conservation strategy should involve the local community, such as Pokmaswas, Pokdarwis, as well as farmers. In this case, the government has initiated a regulation on “Essential Ecosystem Areas”. It is an effort to protect the high-ecological-value areas outside the conservation areas. The biodiversity conservation in the Manggar River can adopt and implement this mechanism. Also, it is necessary to maintain the vegetation around the mangrove forest as a food source. Several unused pond areas are undergoing secondary succession. It gives a positive sign on proboscis monkey conservation in the Manggar River. For the long term plan, monitoring of proboscis monkeys needs to be done periodically to understand the influence of anthropogenic pressure on the population.
5. Conclusion
The estimated range of proboscis monkey population in the Manggar River is from 57 to 69 individuals. It comprises four groups. Meanwhile, the population density is 4.75 individuals/km². The proboscis monkeys were found in the midstream and the upstream area, which is far from the settlements. Currently, the habitat has been fragmented and not connected with other populations. Since the habitat is in a non-conservation area, the first step of the conservation efforts is to build awareness of the local community.

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