

Biodiversity and Spatial Distribution of Hornbills in Pondok Buluh Educational Forest, North Sumatra, Indonesia

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Abstract: Hornbills are large birds, several species of which are protected under national and international conservation legislation and face significant extinction risk. This study was conducted in the Specific Purposes Pondok Buluh Forest Area, North Sumatra, Indonesia, with the aim of identifying hornbill species present, estimating their population density, and characterizing their habitat. Hornbill surveys were carried out using the point count method, which involved direct observation during vocalizations, feeding, and resting activity. Potential nest tree characteristics and food plant availability were assessed using the Rapid Assessment method, and vegetation structure was described using 80×80 m plots. A total of 18 detections were recorded, representing two hornbill species: the Great Hornbill (*Buceros bicornis*) and the Black Hornbill (*Anthracoceros malayanus*). Both species are listed as protected under Indonesian law and are assessed as Vulnerable and Near Threatened, respectively, on the IUCN Red List. Nest trees identified included stone oaks (*Lithocarpus* spp.) and medang (*Litsea angulata*), while key food plants comprised fig (*Ficus benjamina*), nutmeg (*Myristica fragrans*), and several other fruiting tree species. These findings provide baseline biodiversity and habitat data for hornbills in this forest area and underscore the importance of protecting the Pondok Buluh Educational Forest as a viable habitat for threatened avifauna in North Sumatra.

Keywords: Hornbill, Biodiversity, *Buceros bicornis*, *Anthracoceros malayanus*, Point count method, Habitat assessment, Conservation status, North Sumatra

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Introduction

Hornbills are large-sized bird species, belonging to the Family Bucerotidae, called Rangkong or Enggang in Indonesian. According to Ministry of Environment and Forestry (2018) there are 62 species of hornbills that are spread across Africa, tropical Asia, Indonesia and Papua New Guinea and 9 species occur in Sumatra Island (9 species), Indonesia [1]. Hornbills are distributed in Sumatra across natural forests from the northern tip to the southern tip of the Island, mostly limited to the

protected forest areas, national parks, and other conservation areas, besides some other areas that are still forested. Some of the species have a very wide distribution, such as Wreathed hornbill (*Rhyticeros undulatus*), and Oriental pied hornbill (*Anthracoceros albirostris*) which typically can be found in a number of locations in Sumatra as well as other islands. There are also species with a limited distribution due to their specific habitat, such as Wrinkled hornbill (*Aceros corrugatus*) and the Great hornbill (*Buceros bicornis*) which only inhabit lowland forests, hill forests, and swamp forest [2]. Currently, all species of hornbill in Indonesia are categorised as protected birds in accordance with the enactment of Law Number 5 of 1990 regarding Conservation of the Living Natural Resources and its Ecosystem and Government Regulation Number 7 of 1999 about Preserving Flora and Fauna Species. The severe increase in poaching for the illegal trading of hornbills has been paralleled by an increase in demand for these birds, particularly from overseas consumers, the majority of whom are from China. The high rate of deforestation in major hornbill habitats also contributes to classifying several species as critically endangered and listed in Appendix I CITES and in the IUCN Red List [3, 4]. But Jarulisa et al. found that the distribution of hornbills was more dominant in the unprotected areas (66.35%) compared to the protected areas (33.65%) [5].

Dhami, et al. stated that hornbills inhabiting tropical rain forests are typically frugivores [6]. The birds' broad cruising range makes them become effective seed dispersers in disseminating various seeds in the forests. They are found to swallow and digest only the fleshy parts of the fruits they handle and then defecate the seeds intact. Their presence serves as an indicator of the health of a forest that is reflected in the existence of big trees in the forest area. Hornbills require various fruit trees as sources of their food and huge trees with naturally formed tree hollows for nests and breeding. In other words, by protecting the hornbills, forests will be conserved.

Pondok Buluh, an area in Simalungun Regency, North Sumatra, has significant biodiversity potential, including as a habitat for hornbills. The forest surrounding Pondok Buluh, with its remaining large stands of trees, makes it a crucial location for hornbill survival. However, habitat pressures, whether from land clearing, logging, or land-use conversion, can impact hornbill populations in the region. Studies on the presence of hornbills in Pondok Buluh are essential, not only to document local biodiversity but also as a basis for wildlife conservation efforts and sustainable area management. Information on surviving hornbill species, their behavior, and habitat preferences will provide insight into the ecological conditions of the area.

Currently, information on the biodiversity in The Pondok Buluh Forest for Education and Training (Pondok Buluh KHDTK Forest) is still limited to animals and plants in general, while there is still a huge shortage in data on hornbills. Therefore, it is necessary to conduct research on the biodiversity of hornbills in Pondok Buluh KHDTK Forest. Hornbill conservation in this forest requires research to obtain data and information on the species of hornbills, their abundance, and habitat.

Methods

This research was conducted in Pondok Buluh KHDTK Forest which covers an area of 1,272.7 hectares in Simalungun Regency of North Sumatra Province. The Pondok Buluh forest for Education and Training is situated at an altitude of 501 – 1,250 meters above sea level. The topography of the forest varies ranging from gentle, and moderate slopes to steep slopes with the slope angles 2–15%, 15–40% until > 40%. According to Schmith and Ferguson's classification, the climate in Pondok Buluh KHDTK area is categorised as a type A climate with an average rainfall of 14 rainy days per month and an average air temperature of 25,25°C – 26,8°C.

The location of data collection was carried out throughout The Pondok Buluh KHDTK Forest area which was carried out by exploring all areas that were possible to be traveled. Observations started from the Pondok Buluh KHDTK entrance road, the boundaries of the forest area with the Village and within the KHDTK forest area itself, both in the tree preservation area, tracking area and interpretation routes. Meanwhile, in areas that were not possible to be traveled due to the terrain being too steep, no observations were made. The location of the activity can be seen in Figure 1.

Observational data in general are classified as primary and secondary data. Primary data were obtained through direct observations in the research sites. They included:

- (a) Data on the hornbills (the hornbill species, the number of individuals, the time found, and the positions (distance and angle), the activities, the gender, the canopy strata and the forms of interaction among species)
- (b) Data on the birds' habitat that comprised vegetation structure, composition, elevation, and the habitat characteristics. Secondary data consisted of data obtained indirectly or supporting data obtained through literature review, interviews, and other sources. The collected secondary data involved the general conditions of the research sites, supporting

literature on hornbills, the habitat, and hornbill diversity, as well as other information on hornbills obtained through interviews with the local community in the research sites

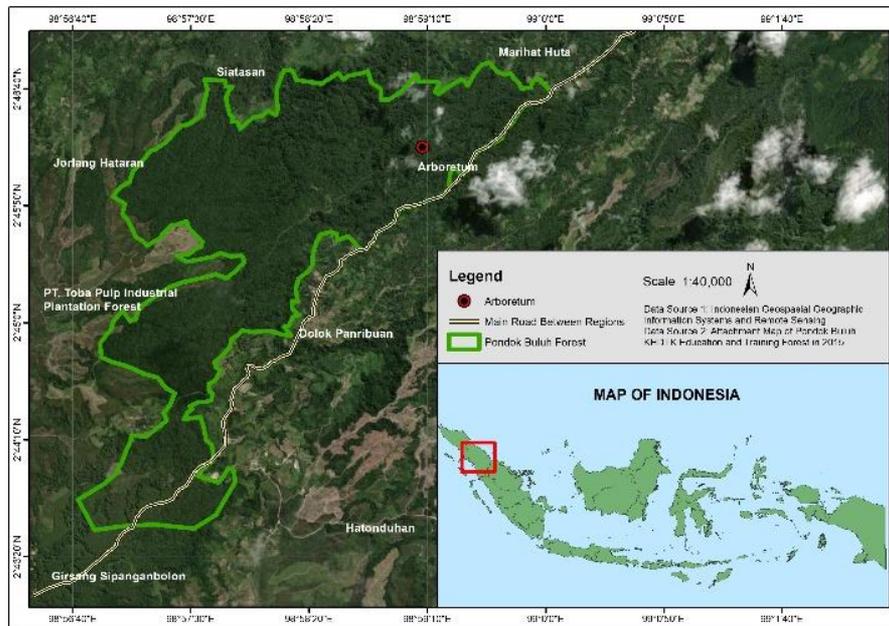


Fig. 1: Map of land cover Pondok Buluh KHDTK Forest for Education and Training

Bird Observation

The implementation of hornbill inventory used a Concentration Point Count method with reference to MacKinnon, et al. [7]. A sample unit form of bird observation is shown in Figure 2.

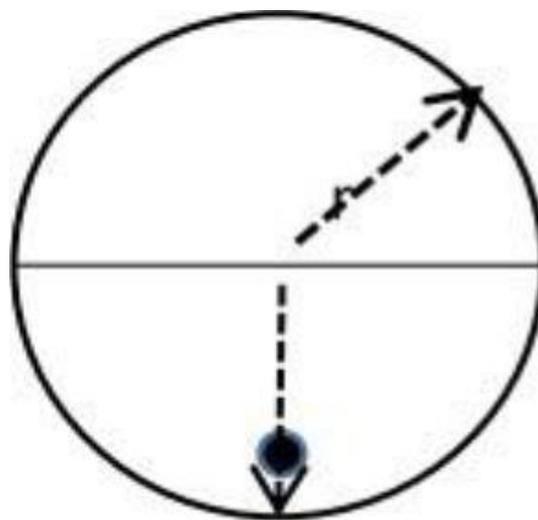


Fig. 2: Hornbill Inventory Design with Concentration Point Count Method

Data collection on the existence of hornbills was conducted with the use of Concentration Point Count Method. The method was determined with field observation and information obtained from the local community about the locations in which the hornbills were often visible [8]. Concentration Point Count method is a method in that observation is conducted directly or a direct contact with a flock of hornbills, observed when they are performing the calling activity, feeding and resting [9]. The observations were conducted simultaneously at along the birds' daily movement path to minimise the chance of double counting the hornbills. The observations were made at time intervals between 07.00 and 09.00 for morning period, and

between 11.00 and 13.00 for the day time period, and between 15.00 and 17.00 for an afternoon period. These different time periods represented the hornbills' feeding and resting activities, enabling higher chances of observing the birds. The data obtained consisted of the species of hornbills, the time of encounter, the number of individuals, the type of encounter (visual/audio) and the location of encounter. At every point, the observations were repeated 4 times.

The identification of hornbill species was conducted through direct observations in the research sites based on the combinations of several unique features of the birds. These features included their general appearance, vocalisation, and behaviours [10]. It is also important for matching as many parts of the birds as possible, particularly their diagnostic features found in the Manual Book for Field Observation of Birds in Sumatra, Java, Bali, and Borneo [7]. Data recording was carried out when observing the birds in the entire area of the observation sites in 15-minute intervals for 2 hours in the morning, day and afternoon periods in every observation point.

Vegetation Observation

Data on the potential tree characteristics for hornbill nests and the availability of food plants were collected with Rapid Assessment method in the surrounding observation sites [7] (MacKinnon et.al, 2010). The observation of vegetation in the hornbill habitat used a single-tier plot method [11]. Two sample plots were created, and with the use of purposive sampling each plot was placed in the transects where hornbills were often visible doing their activities. The plots measured 80 x 80 m² were used for collecting data on the vegetation with a focus on the tree growth rate. The parameter that was measured directly in the sites included the species (local and scientific), the number of individuals, the breast-height tree diameter and the tree height.

Data Analysis

Data analysis in this research used a descriptive analysis of qualitative research. The hornbills observed were recorded in tabulation consisting of all data regarding direct contact with the birds, the locations, the time and the frequency of the contact. In addition to the data on the observed hornbills, the analysis also included data on the trees in the habitat where the hornbills were found perching, and the potential of the fruit trees as sources of their food and the potential tree characteristics for hornbill nests. Results from data interpretation were organised and written systematically.

Results and Discussion

Potential and Distribution of Hornbills

Based on the results of observations during the study, it shows that in KHDTK Pondok Buluh there are two types of hornbills. The differences between the two types of hornbills are clearly visible from the color of the feathers and body shape.

Two species of hornbills which recorded in Pondok Buluh KHDTK Forest were Great Hornbills (*Buceros bicornis*) and Black Hornbills (*Anthracoceros malayanus*) (Figure 3).



Fig. 3: The Great Hornbills (left) and the Black Hornbills (right) [12]

The Great Hornbill (*Buceros bicornis*) is large (125 cm), black and cream in color. There is a wide black line across the white tail and a yellowish-white line on the black wings. The beak and horns are yellow, the shape of the horns is flat and concave upwards. The face is black, the neck and chest are white with feathers sometimes stained with yellow. Meanwhile,

5	Tracking trail	✓	-	-	-	1	1	155o	300	rainy/ overcast
	Interpretation path 1	✓	-	-	1	-	-	25o	300	
	Interpretation path 2	✓	-	-	-	1	1	100o	400	
	Interpretation path 3	✓	✓	1	-	1	2	125o; 80o	400; 75	
	Interpretation path 4	✓	-	-	-	1	1	55o	500	
	Interpretation path 5	-	-	-	-	-	-	-	-	
	Interpretation path 6	-	-	-	-	-	-	-	-	
	Interpretation path 7	-	-	-	-	-	-	-	-	
6	Tracking trail	✓	-	1	-	1	2	100o; 75o	150; 250	sunny/ cloudy
	Interpretation path 1	✓	✓	1	1	1	3	90o, 10o; 55o	75; 200; 200	
	Interpretation path 2	✓	-	1	-	1	2	40o; 75o	300; 200	
	Interpretation path 3	✓	-	1	-	1	2	155o; 80o	300; 200	
	Interpretation path 4	✓	-	1	-	1	2	30o; 350o	300; 150	
	Interpretation path 5	✓	-	1	-	-	1	145o	300	
	Interpretation path 6	✓	-	1	-	-	1	35o	100	
	Interpretation path 7	-	-	-	-	-	-	-	-	
7	Tracking trail	✓	-	1	-	1	2	125o; 35o	200; 350	sunny/ cloudy
	Interpretation path 1	✓	-	1	-	1	2	15o; 250o	200; 300	
	Interpretation path 2	✓	-	1	1	1	3	30o; 25o; 180o	200; 300; 200	
	Interpretation path 3	✓	-	1	1	-	2	65o; 15o	200; 250	
	Interpretation path 4	✓	-	1	-	1	2	225o; 100o	100; 200	
	Interpretation path 5	✓	-	-	-	1	1	185o	150	
	Interpretation path 6	✓	-	1	-	-	1	75o	300	
	Interpretation path 7	-	-	-	-	-	-	-	-	
Total Frequency:		48	4	30	13	26	68			

During the seven-day observation, hornbills were found in different locations along the observation route. Nine teams spread out at different points found 68 encounters with hornbills both visually and audibly (sound) (Tabel 1). From the observations, the research team found that the most observation points were on the tracking trail, interpretation path 1, 2, 3, 4, 5 and 6. No hornbills were found on interpretation path 7 and 8. This is possible because interpretation paths 7 and 8 are closer to the main road. The noise of passing vehicles and the hustle and bustle of humans seems to be quite disturbing for hornbills so that these birds tend to avoid the interior of the KHDTK forest.

The study also showed that hornbills like forest environments that are close to community agricultural areas. This may be because agricultural areas provide the main food for hornbills such as bananas, papaya, guava, and other fruits. The awareness of the community living adjacent to this forest area is also the reason for the acceptance of hornbills looking for food in community agricultural areas [13]. The community is not disturbed by the presence of hornbills because they do not interfere too much with the harvest. It seems that hornbills like areas that are far from the hustle and bustle of humans such as main roads and settlements, but like forest environments that are close to agricultural areas as one of the sources of food for these animals. All observation points are located in the KHDTK Diklat Pondok Buluh Forest area. The meeting points with the hornbills are presented in Figure 4.

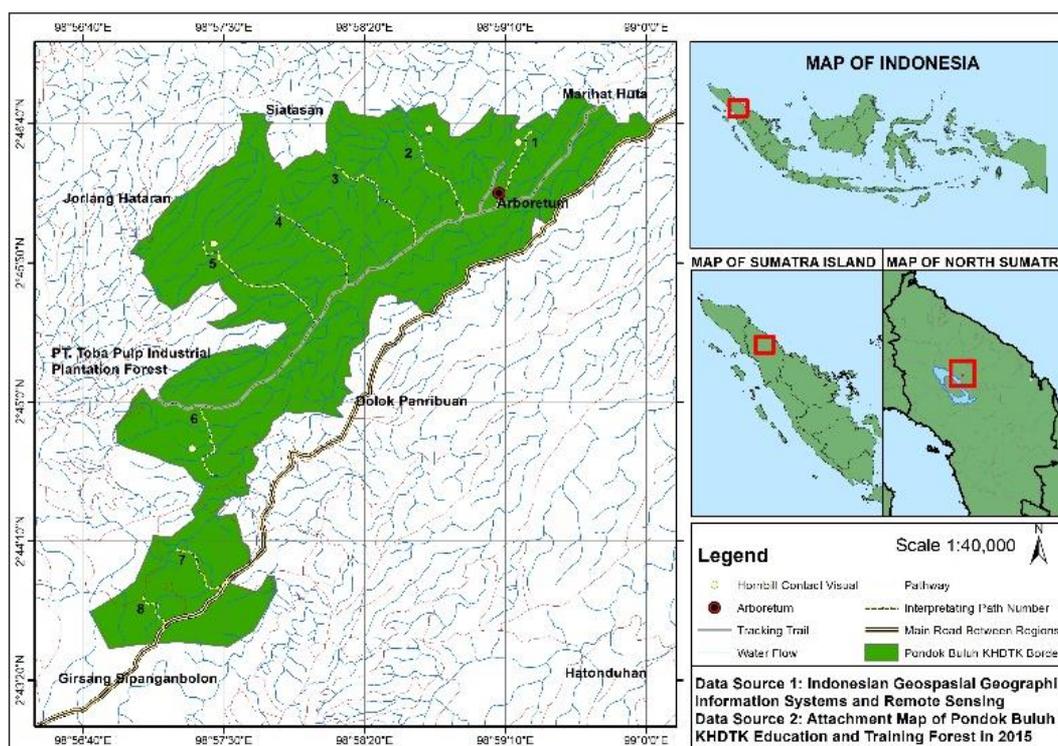


Fig. 4: Contact Points with Hornbills in Pondok Buluh KHDTK Training and Education Forest Area

The number of individuals encountered during the study was at least 13. From the 68 encounters, 48 were found audibly and 4 visually. The highest hornbill activity occurred in the morning with 30 encounters followed by 26 encounters in the afternoon and 13 encounters during the day. The high activity of hornbills in the morning is because in the morning hornbills begin to actively make sounds and fly above the treetops to look for food. Hornbills will reduce their activity during the day when the air temperature begins to rise and will be active again in search of food in the afternoon when the air temperature begins to decrease. Observation data shows that hornbills are not active during rainy days. Once the rain stops, hornbills return to activity during the day until the afternoon. Hornbills also like cloudy weather where the air temperature is quite friendly for this flock of birds.

The Potential of Nest Trees and the Availability of Food Plants for Hornbills

The habitats of hornbills are generally located in upland tropical forests with tree characteristics of more than 10 metres high and a diameter of more than 35 cm. The existence of these trees as a source of food and for hornbill nest represented two significant aspects for the conservation of hornbills. Zheng Xi et al. stated that the dense natural forest is also home to the largest hornbill in China's Shorea-dominated dipterocarp rainforest with a large population of *Tetrameles nudiflora* large deciduous trees that can provide potential nesting trees for hornbills [14]. Hornbills used these tall and large trees in the three observation locations for activities, such as perching, foraging for food, taking shelter and nesting [15]. The trees that became hornbill nest included Stone Oak and Medang trees with a diameter of more than 65 cm, located in areas with steep topography and many large trees (Figure 5).

According to Yeap et al., the availability of food in a particular type of habitat is one of the factors affecting the presence of hornbills. In Pondok Buluh KHDTK Forest, hornbills were often found perching on various tree species, such as Stone Oaks (*Lithocarpus* spp), Indonesian Bay Leaf (*Syzygium polyanthum*), Medang Trees (*Litsea angulata*), Chempedak (*Artocarpus integer*), Albizia (*Albizia chinensis*), Stinky Beans (*Parkia speciosa*), and Johey Oaks (*Artocarpus odoratissimus*) [16]. These tree species were large trees with typical trunk circumference of > 80 cm. In addition to their large size, these trees also produced fruit which served as food source for hornbills in the forest area as well as their habitat and nests [17]. Based on the information obtained from the local community, hornbills also fed on agricultural crops, such as bananas.



Fig. 5: One of Hornbill Nest Trees in Pondok Buluh KHDTK Forest

Table 2: Name of tree as a food source and nesting place for hornbills in Pondok Buluh KHDTK Forest

No	Species	Local Plant Names	Fruit Tree	Nest
1	<i>Ficus benjamina</i>	Weeping fig	✓	-
2.	<i>Myristica fragrans</i>	Nutmeg	✓	-
3.	<i>Canarium vulgare</i>	Canarium	✓	-
4.	<i>Litsea glutinosa</i>	Bollygum	✓	-
5.	<i>Melia azedarach</i>	Chinaberry	✓	-
6.	<i>Litsea angulata</i>	Medang Tree	✓	✓
7.	<i>Artocarpus integer</i>	Chempedak	✓	-
8.	<i>Albizia chinensis</i>	Albizia	✓	-
9.	<i>Parkia speciosa</i>	Stinky Beans	✓	-
10.	<i>Artocarpus odoratissimus</i>	Johey Oaks	✓	-
11.	<i>Lithocarpus</i> spp.	Stone Oaks	✓	✓
12.	<i>Syzygium polyanthum</i>	Indonesian Bay Leaf	✓	-
13.	<i>Musa</i> sp.	Banana	✓	-

Hornbills spend most of their time at the top of the forest canopy, and their main diet consists of fruits, insects, small reptiles, rodents, and small birds [18]. Ecologically, the role of hornbills as seed dispersals agents are extremely significant for the sustainability and stability of forest ecosystems. The seeds from the fruit consumed by hornbills are not digested and will be defecated intact. These seeds will grow and become new trees [19]. The reciprocal relationship between plants as producers and hornbills as consumers is closely related. Consequently, if one of these parties experiences an extinction, the sustainability of the forest ecosystem will be seriously affected [20].

Threats to Hornbill Survival and Habitat

All species of hornbills in Indonesia are categorised as protected birds in accordance with the Government Regulation Number 7 of 1999 about Preserving Flora and Fauna Species. The IUCN also classify hornbills as critically endangered species [1]. Threats to hornbills in Pondok Buluh KHDTK Forest affected the birds survival indirectly, as the threats essentially brought significantly serious impacts on their habitat due to various human activities, such as forest destruction for firewood, palm sap harvesting, bamboo shoot harvesting, camping and poaching of small birds [21]. These threats could damage the

stability of the forest ecosystem, endangering the existence of hornbills in Pondok Buluh KHDTK Forest for Education and Training because of their disturbed habitat conditions.

Several members of the local community residing around Pondok Buluh KHDTK Forest stated that hornbills often flew across and perched on trees in their gardens. They had become accustomed to the presence of hornbills. According to Pawar et al. apart from primary forest areas, hornbills were also visible in the buffer zones of agroforestry to search for alternative food [22]. The local community recognised that the hornbills were critically endangered and were protected by the government. Therefore, they were reluctant to hunt these birds due to the risks of serving a sentence in prison if caught hunting the birds.

Conclusion

In conclusion, based on the research conducted, it could be concluded that:

- (i) there were two species of hornbills inhabiting Pondok Buluh KHDTK Forest, namely the Great Hornbills (*Buceros bicornis*) and the Black Hornbills (*Anthracoceros malayanus*)
- (ii) The potential tree characteristics for hornbill nests consisted of Medang Trees and Stone Oaks
- (iii) The availability of food plants for hornbills in the research site in Pondok Buluh KHDTK Forest was supported by the existence of several tree species including Stone Oaks, Indonesian Bay Leaf, Medang Trees, Chempedak, Albizia, Stinky Beans and Johey Oaks
- (iv) The Pondok Buluh KHDTK Forest for Education and Training has tourism potential of Hornbill Watching in the surrounding area of the guest house

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Ethics

This research involves protected species.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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