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HABITAT CHARACTERISTICS OF WREATHED HORNBILL (*Rhyticeros undulatus* SHAW, 1881) IN SOKOKEMBANG FOREST, CENTRAL JAVA, INDONESIA

KARAKTERISTIK HABITAT JULANG EMAS (*Rhyticeros undulatus* SHAW, 1881) DI HUTAN SOKOKEMBANG, JAWA TENGAH, INDONESIA

Fahma Wijayanti*[1], Eka Apriani[1], Narti Fitriana[1], Ulfah Fajarini[2]
[1]*Department of Biology, Faculty of Science and Technology, UIN Syarif Hidayatullah Jakarta, Ir. H. Djuanda St, No. 95, Ciputat, South Tangerang, Banten, Indonesia*
[2]*Faculty of Tarbiyah and Teacher Training, UIN Syarif Hidayatullah Jakarta, Ir. H. Djuanda St, No. 95, Ciputat, South Tangerang, Banten, Indonesia*
**Corresponding author:* fahma.wijayanti@uinjkt.ac.id

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Abstract

Wreathed hornbill is a bird species that can be a bio-indicator and has a role in forest regeneration. This study aimed to estimate the population density of the wreathed hornbill and to identify its habitat characteristics. Bird populations were counted using the Variable Circular Plot (VCP) method. Habitat characteristics were then assessed by measuring environmental factors and analyzing vegetation within 20 × 20 m plots established at foraging, roosting, and nesting sites. Data analysis involved determining individual density, distribution pattern, conducting vegetation analysis, and performing a Principal Component Analysis (PCA). Wreathed hornbill that was found are 20 ± 1.2 individuals. The population density is 7.047 individuals/km^2 and has a clustered distribution pattern. The habitat of the wreathed hornbill is characterized by a vegetation composition consisting of 14 species from 8 families. Types of trees with the highest INP were Ficus mbulu (*Ficus annulata*) (INP 54%), Ficus krandan (*Ficus* sp1) (INP 46%), and Ficus bulu so (*Ficus globosa*) (INP 32%). There are 9 types of foraging trees, 10 species of roasting trees, and 1 nesting tree species used by the wreated hornbill. Based on PCA, wind speed and light intensity are environmental factors that have a correlation with the population density of the wreated hornbill in Sokokembang Forest.

Keywords: Habitat characteristic; Population density; Sokokembang Forest; Wreathed hornbill

Abstrak

Julang emas (wreathed hornbill) adalah burung yang berfungsi sebagai bioindikator dan berperan dalam regenerasi hutan. Penelitian bertujuan untuk memperkirakan kepadatan populasi dan mengidentifikasi karakteristik habitatnya. Populasi burung dihitung menggunakan metode Petak Melingkar Variabel (Variable Circular Plot - VCP). Karakteristik habitat dinilai dengan mengukur faktor-faktor lingkungan dan melakukan analisis vegetasi di dalam petak 20 × 20 m di lokasi mencari makan, tempat bertengger, dan sarang. Analisis data meliputi penentuan kepadatan individu, pola sebaran, analisis vegetasi, dan Analisis Komponen Utama (Principal Component Analysis - PCA). Total individu rangkong jambul yang ditemukan adalah 20 ± 1,2 individu. Kepadatan populasinya mencapai 7.047 individu/km^{2}dan menunjukkan pola sebaran berkelompok (clustered distribution pattern). Habitat dicirikan oleh komposisi vegetasi yang terdiri dari 14 spesies dari 8 famili. Jenis-jenis pohon dengan Nilai Penting (INP) tertinggi adalah ficus mbulu (Ficus annulata) (INP 54%), ficus krandan (Ficus sp1.) (INP 46%), dan ficus bulu so (Ficus globosa) (INP 32%). Terdapat 9 spesies pohon pakan (foraging), 10 spesies pohon tempat bertengger malam (roosting), dan 1 spesies pohon sarang (nesting) yang digunakan oleh rangkong jambul. Berdasarkan PCA, kecepatan angin dan intensitas cahaya adalah faktor lingkungan yang memiliki korelasi dengan kepadatan populasi rangkong jambul di Hutan Sokokembang.

***Kata Kunci**: Hutan Sokokembang; Julang emas; Karakteristik habitat; Kepadatan populasi*

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INTRODUCTION

The wreathed hornbill (*Rhyticeros undulatus* Shaw, 1881) is a bird from the *Bucerotidae* family whose dispersion in Indonesia includes Sumatra, Kalimantan, and Java Islands. According to Al-Huda et al. (2024), forest destruction in the Sunda region has been extensive due to commercial and illegal logging, as well as conversion to agriculture (particularly plantations), and increasing human population pressure, posing a threat to the existence of the wreathed hornbill. A wreathed hornbill was observed in the Sokokembang Forest located in Sokokembang Hamlet, Kayupuring Village, Central Java (Rijal, 2018). Sokokembang Forest is one of the remaining hilly tropical rainforests on the island of Java, which has a potential habitat area of 65.69 km^2 (Al-Huda et al., 2024). According to Liang et al. (2024), hornbills consume and potentially disperse seeds of many plant species beyond the physical capabilities of other avian frugivores. Hornbill habitat quality was poor in most of the reserve, with low tree density and basal area with only a few patches with higher tree density. Oriental pied-hornbills were associated with lower elevations and higher fruiting tree density.

The wreathed hornbill population in the world has decreased due to habitat destruction and fragmentation. The expansion of agricultural activities and non-timber extractions are some of the threats to the wreathed hornbill habitat found in Sokokembang Forest. This can lead to reduced fodder plants and nest trees, and the loss of the wreathed hornbill's natural habitat. The ecological study of the wreathed hornbill in Sokokembang Forest can provide initial information about the population and habitat characteristics of the wreathed hornbill in Sokokembang Forest. The study objective is to analyze the wreathed hornbill population density in Sokokembang Forest, and these data are used to determine the habitat characteristics of the wreathed hornbill in Sokokembang Forest. This Accurate information is needed to formulate conservation strategies for the wreathed hornbill.

MATERIALS AND METHODS

The research was carried out in Sokokembang Forest, Petungkriyono, Central Java, Indonesia (109'420E-109’45 30” E; 7’70S-7'40S), in March to June 2020. The survey method with purposive sampling was applied in the area that had wide visibility based on information on wreathed hornbill encounters in previous studies. Data were collected using the Variable Circular Plot (VCP) method (Bibby et al., 2000). This method is carried out by standing upright at each point in the transect with an observation radius of 500 m for observation points. There were 4 plots within the 2.3 km transect length. Data taken were the number of wreathed hornbill individuals, observed activity, habitat information, coordinate points, and the distance of the bird to the center of the point. The observation was repeated three times at each observation point. In addition, several environmental factors were measured, including weather conditions, altitude, temperature, humidity, light intensity, and wind velocity. At the wreathed hornbill encounter location, the coordinates were recorded using GPS.

Vegetation analysis was carried out by creating a habitat profile from a 20 × 20 m quadrant. Furthermore, data analysis of the wreathed hornbill population and dispersion pattern was carried out. The formula used to measure the population is by using the population density D= N/A, where D= population density (individuals/km^2), N= total individual (bird), A= the area (πr^2, π= 3.14).

The relationship between environmental physical factors and the population density of wreathed hornbill was also analyzed. The standard dispersion index {IP) has an interval of -1.0 to 1.0 with a 95% confidence level at the limits of 0.5 and -0.5. The IP value is used to show the trend of the wreathed hornbill dispersion pattern in Sokokembang Forest with the following values, IP= 0 indicates a random dispersion pattern; IP >0 indicates a clumped dispersion pattern IP <0 indicates a uniform dispersion pattern. The relationship between wreathed hornbill density and environmental parameters was analyzed using the Principal Component Analysis (PCA) method. PCA analysis was carried out using Statistical Product and Service Solution (SPSS) 21.0 software.

RESULTS

A total of 20 ± 1.2 wreathed hornbill individuals were observed from four observation stations in Sokokembang Forest. The highest number of wreathed hornbill individuals was observed at station I, while the lowest number was observed at station III. The density of the population is about 7.047 individuals per square kilometer (Table 1). The wreathed hornbills in Sokokembang Forest were

observed flying in groups of 2 to 5 individuals. The dispersion pattern of the wreathed hornbill in Sokokembang Forest is clumped with an Index of Clumping of more than zero (Ip >0).

Table 1. Density of population

Station	Number of individuals observed	Density of population (ind/km^2)
I	9 ± 2	11.53
II	6 ± 3	7.69
III	2 ± 2	2.56
IV	5 ± 1	6.41
		7.047

The composition of vegetation in Sokokembang Forest consists of eight families with 14 tree species found in the wreathed hornbill habitat (Table 2). The *Ficus annulata* is the dominant species with an IVI of 54%, then *Ficus* sp1. with 46%, and *F. globosa* with 32%. Other species have a lower IVI in the wreathed hornbill habitat with an IVI of 12% to 25%. The wreathed hornbill feed species in the Mendiro Forest consisted of the *Moraceae* and *Malaceae* families with a total of 8 species.

Table 2. Importance value index (IVI) vegetation habitat of the wreathed hornbill

Family	Species	IVI (%)
Calophyllaceae	*Mesua ferrea*	12
Lauraceae	*Litsea* sp.	12
Lecythidaceae	*Baringtonia racemosa*	18
Moraceae	*Artocarpus elasticus*	25
Moraceae	*Ficus globosa.*	32
Moraceae	*Ficus annulata*.	54
Moraceae	*Ficus* sp.	46
Moraceae	*Ficus variegata*	12
Moraceae	*Ficus* sp.	13
Meliaceae	*Sandoricum koedjape*	15
Rubiaceae	*Nauclea optusa*	12
Rubiaceae	*Nauclea lanceolata*	12
Sapindaceae	*Acer niveum*	16
Staphyleaceae	*Turpinia spaerocarpa*	23
		300

Table 3. Tree utilization and plant phenology

Species	Utilization	Plant phenology
Artocarpus elasticus	N, F, R	FL, YF
Mesua ferrea	F, R	RF
Ficus globosa	F, R	Fr
Ficus sp.	F, R	RF
Ficus annulata	F, R	RF, F
Ficus variegata	F, R	RF
Sandoricum koedjape	-	FL
Turpinia spaerocarpa	R	NF
Nauclea optusa	F, R	RF
Ficus sp.	-	NF
Nauclea lanceolata Blume	-	NF
Baringtonia racemosa L.	-	Fr
Litsea sp.	F, R	Fr
Acer niveum Blume	F, R	Fr

Note: F= foragging site; R= roasting site; N= nesting site; FL= fruitless; YF= young fruit full; RF= ripening fruit; Fr= flowering; NF= not fruit tree

Wreathed hornbill feeding activity was observed in strata 1 and 2 with a height above 15 m. The habitat of the wreathed hornbill fodder tree has a height between 23 to 27 m. The trees utilized as perches are *A. elasticus, M. ferrea, F. globosa, Ficus* sp., *F. annulata., F. variegata, T. spaerocarpa, N. optusa, Litsea* sp., *A. niveum,* and *D. rao.* Wreathed hornbill in Sokokembang Forest were observed nesting in natural holes in the trunks of *A. elasticus. A. elasticus* used as nests (Table

3) by wreathed hornbill in the Sokokembang Forest are located on Sepacet Hill at an altitude of more than 900 masl. The nest tree is 35 m high with a diameter at breast height (DBH) of 80 cm. Sokokembang Forest is located in the first branching with characteristics of tree height is 30.3 cm, nest height 26.5 m, and nest hole size 20 × 10 cm. Measurements of physical environmental factors were carried out at each observation station each time a golden hornbill was encountered (Table 4).

Table 4. Physical parameters of the environment in Sokokembang Forest

Station	Abiotic factors				
	Temperature (°C)	Humidity (%)	Wind speed (m/s)	Light intensity (klx)	Height (masl)
1	25.52 ± 1.30	85.64 ± 3.28	0.15 ± 0.53	16.82 ± 5.09	789
2	27.34 ± 5.20	78.77 ± 15,17	0.61 ± 1.33	12.72 ± 5.99	752
3	24.23 ± 0.25	91.67 ± 4.73	1.20 ± 2.08	13.88 ± 4.73	667
4	24.10 ± 0.72	85.73 ± 5.86	0.28 ± 0.49	10.41 ± 6.84	671
Average	25.30	85.45	0.56	13.46	719.75

Based on the PCA results, 5 main components were obtained. Each component has a different variance value and total eigenvalue. Of the five components, only two have a cumulative variance of 72.54% (Table 5). This proportion is considered sufficient to represent the total variance of the data, as the cumulative variance falls within the 70−80% range.

Table 5. Total eigenvalue and cumulative variance of Principal Component Analysis (PCA)

Main component	*Initial eigenvalue*		
	Total	% Variance	% Comulative variance
1	2.364	47.274	47.274
2	1.263	25.266	72.540
3	0.747	14.936	87.477
4	0.502	10.049	97.526
5	0.124	2.474	100.000

The PCA results show that there are two main components that have an influence, namely wind speed and light intensity. PCA shows the Eigenvalues of the variables against the main components in Table 6.

Table 6. The eigenvalue of the variables against the main components

Variable	Main component - 2
Temperature	-0.293
Humidity	0.159
Wind speed	0.834
Light intensity	-0.712
Height	0.351

DISCUSSION

The highest density of the wreathed hornbill was found at station I with 11.53 individuals/km^2, and the lowest was at station III with a density of 2.56 individuals/km^2. According to Kinnaird et al. (1996), the density of wreathed hornbill was found to be greater at observation points surrounded by open and hilly areas. Such habitat conditions support the golden hornbill in moving and searching for food sources. The wreathed hornbills have a large body size that requires a large space to support their activities. Different environmental parameters,, such as the nearest distance to the water source, canopy cover, and nearest distance to forest habitat, significantly affected bird occurrences. In Sokokembang Forest, all stations are located on the river path (maximum 0.5 km from the river), but station I is on the edge of the forest and adjacent to the plantation, while station III is in the middle of the forest and far from the plantation (>3 km). According to Shah and Sharma (2022), the species richness was positively correlated with the nearest distance to agricultural land for both seasons; however, it decreased with increasing distance to water sources and canopy cover.

The population density of wreathed hornbill in Sokokembang Forest (7.047 individuals/km^2) is smaller than the population recorded on Mount Ungaran, based on

Rahayuningsih et al. (2017), which was 15 individuals/km^2, and the population recorded in fragmented lowland tropical forests of Arunachal Pradesh, India which was 19.1 individuals/km^2 (Krishna et al., 2012). However, this amount is greater than in protected areas in the Indian Eastern Himalayas which is 0.49 individuals/km^2 (Pradhan et al., 2024). This shows that Sokokembang Forest still has potential as a habitat for wreathed hornbills. A factor that often stands out is animal behaviors that are intolerant of interspecific and intraspecific interactions in the ecosystem. Interactions that occur in a population can be in the form of competition if organisms of the same species (intraspecific) or different species (interspecific) are using the

same natural resources. In Sokokembang Forest, the wreathed hornbill has an interspecific interaction in the form of competition in utilizing food sources with Javan gibbon (*Hylobates moloch*) and binturong (*Arctictis binturong)* (Setiawan et al., 2012; Al-Huda et al., 2024). Based on the research by Rijal (2018), the Sokokembang forest is a habitat for 38 species of birds, 24 of which utilize the forest vegetation as foraging and dwelling places.

The clumped dispersion pattern of the wreathed hornbill in Sokokembang Forest shows non-uniform environmental conditions. This means that the habitat resources that the wreathed hornbill can use are only found in certain areas of Sokokembang. According to Pradhan et al. (2024), a grouping of individual birds is caused by response to changes in weather, differences in habitat conditions, reproductive process, and social attractiveness. By grouping, individuals can cooperate in foraging and reduce predation risk. According to Wijerathne et al. (2024), wreathed hornbill flies in search of fruit trees and often mingle with other *Bucerotidae* species in fruiting trees. The unequal fruiting period and the dispersion of food sources cause the birds of the *Bucerotidae* family to gather together in a group to look for fruiting trees, groups of wreathed hornbills will move when fruiting ends to areas where fodder trees are experiencing peak fruiting. Wreathed hornbills are observed flying in a group heading in the same direction.

The species of trees that served as food sources for the wreathed hornbill in Sokokembang Forest include *A. elasticus*, *M. ferrea*, *F. globosa*, *Ficus* sp1., *F. annulata*, *F. variegata*, *N. optusa*, *Litsea* sp., and *A. niveum* (Table 3). The *Ficus* species is one of the dominant tree species in the Sokokembang Forest. The dominance of tree species is related to a source of food, perch, and the nest of wreathed hornbill in Sokokembang Forest. The selection of *Ficus* fruit as feed for *Bucerotidae* is due to the high sugar and calcium content. However, the wreathed hornbill does not use *Ficus* fruit as the main feed as a feed distribution strategy to reduce the level of competition. According to Liang et al. (2024), Most hornbills are sedentary and live in defined territories. Sometimes the forest dwellers fly beyond their territories to search for fruit.

The wreathed hornbill in Sokokembang Forest also uses other tree species as a source of food, including *A. elasticus*, *M. ferea*, *N. optusa*, *Litsea* sp., and *A. niveum*. According to the results of the vegetation, analysis found that the wreathed hornbill feed species in the Mendiro forest consisted of the *Moraceae* and *Malaceae* families with a total of 8 species. To determine the potential plant of wreathed hornbill feed use the index of Important Score in each species. The highest potential plant for wreathed hornbill feed was, *Ficus variegata* (87.15%), *Ficus racemosa* (30.46%), *Ficus retusa* (26.36%), *Artocarpus elasticus* (21.95%), *Ficus hispida* (17.84%), and *Ficus Benjamina* (16.79%). According to Liang et al. (2024), an Asian hornbill database for frugivory and seed dispersal research hornbill consume and potentially disperse seeds of many plant species that would be beyond the physical capabilities of other avian frugivores. They were also able to recover positive relationships between hornbill beak sizes and the size of the fruits and seeds they consumed. The size of fruits or seeds consumed by hornbills (median length= 19.6 mm, median width= 15.9 mm). According to Kitamura (2011) hornbills might provide good seed dispersal services for most plant species they consume by distributing seeds away from the parent plants, where seed retention times for large-seeded plants were 46–97 min.

The wreathed hornbill in Sokokembang Forest utilizes 10 types of trees for fodder, perch, and nest trees. This is related to the utilization of strata by wreathed hornbills in strata 1 and strata 2 with tree heights of more than 30 m (Nugroho, 2000). According to Setiawan (2022), the *Bucerotidae* group in Asia is generally found in trees with a height of more than 15 m and a diameter of more than

40 cm. This is influenced by the morphology of the large *Bucerotidae* with a total body length between 65 to 170 cm and body weight between 290 to 4.200 g. The use of the upper strata can facilitate the movement of the wreathed hornbill to fly because of its large body morphology and reduce competition with other frugivorous species (Liang et al., 2024). In Sokokembang Forest, visitations on the fruiting trees were highest in the morning at around 6–8 o'clock and 15–17 o'clock. According to Naniwadekar et al. (2019), in the breeding season, while activity was higher in the morning, there was some activity throughout the day. In the non-breeding season, there were three distinct periods of activity between 5 and 6 h, 8–10 h, and after 14 h. The male: female sex ratio of wreathed hornbills in Sokokembang Forest at the time of the study was 1.2: 1. According to Kinnaird and Brien (2007), this ratio indicates that the population is not in the breeding season. The sex ratio will be dominated by males as females incubate the eggs in the breeding season.

The species of trees used as perches by the wreathed hornbill were *A. elasticus*, *M. ferrea*, *F. globosa*, *Ficus* sp1., *F. annulata*, *F. variegata*, *T. sphaerocarpa*, *N. optusa*, *Litsea* sp., and *A. niveum*. The wreathed hornbill in Sokokembang Forest was also observed perching on the rau tree (*Dracontomelon dao*). Based on the vegetation profile of the perched habitat, the wreathed hornbill utilizes trees with a height of between 15 m to 27 m. According to Nugroho (2000), the wreathed hornbill is always active on strata 1 and 2 trees with a height of more than 30 m. Most *Bucerotidae* return nightly to the same perch or have a fixed selection of sites within their territorial area between which each individual moves alternately at certain intervals (according to the breeding season) throughout the year. The home range of the wreathed hornbill varies between 3.7 km ^{2} (breeding season) to 14.7 km 2 (non-breeding season) (Utoyo et al., 2017).

The wreathed hornbill in Sokokembang Forest was observed nesting in natural holes in the trunk of *Artocarpus elasticus*. In addition to the bando tree, *Litsea* sp. also has the potential as a nest tree. The Bando tree used as a nest by wreathed hornbill in the Sokokembang Forest is located on Sepacet Hill at an altitude of more than 900 masl. The nest tree height is 35 m with a diameter at breast height of 80 cm. According to Rahayuningsih et al. (2017) one of the conditions for a tree to be used as a wreathed hornbill nest is a diameter that is suitable for the wreathed hornbill's body size, which is more than 60 cm.

The availability of nest trees is one of the important factors to maintain the existence of the wreathed hornbill in Sokokembang Forest. Nests are needed by the wreathed hornbill during the breeding season to lay eggs, incubate, and nurture their young. The nest hole in the bando tree used by the wreathed hornbill is a natural tree hole with a height of 20 m facing Northeast. Around the nesting habitat, two male and female wreathed hornbill individuals were observed perching.

Habitat selection by the wreathed hornbill is influenced by the availability of fodder and nest trees with specific characteristics. According to Combrink et al. (2017), parameters that influence the selection of wreathed hornbill nest trees are nest tree height, diameter, branch-free height, the distance between the nest tree and fruit trees or food sources, canopy area of the nest tree, nest hole's depth and area, and nest location from the soil surface. Based on the environmental physical parameters measurement results, Sokokembang Forest has an average air temperature of 25.30 °C and an average humidity of 85.45% (Table 4.). Sokokembang Forest has an average wind velocity of 0.56 m/s and an average light intensity of 13.46 klx. Based on data from the Meteorology, Climatology, and Geophysics Agency in 2022, rainfall in Pekalongan Regency in March 2017 was in the normal category with rainfall ranging from 100–400 mm.

Variables of environmental parameters wind velocity and light intensity, show a relationship with greater eigenvalue (>0.5) compared to temperature, humidity, and altitude (Table 5). Wind velocity has an eigenvalue of 0.834, while altitude has an eigenvalue of -0.712 (Table 5). Environmental parameters affect the presence of animal species in an area. Based on PCA results, wind velocity is one of the environmental factors that influence the individual density of the wreathed hornbill in Sokokembang Forest (Table 6). Wind velocity can affect the wreathed hornbill flying activity. According to Kinnaird et al. (1996), the flapping sound of the wreathed hornbill's wings occurs due to the flow of air on the wings that are not covered with fine feathers like other birds. When the wind velocity tends to be strong, the wreathed hornbill will choose to

perch, which means that appropriate wind velocity can affect the presence of the wreathed hornbill in Sokokembang Forest.

Light intensity is also an environmental factor that has an influence on the individual density of the wreathed hornbill in Sokokembang Forest. Sunlight can also affect the flying activity of the wreathed hornbill. According to Rachmawati (2013), the wreathed hornbill also requires sunlight to fly by utilizing the upward movement of air. The intensity of light affects the wreathed hornbill's time to move as seen in the morning, afternoon, and evening. Wreathed hornbill activity is bimodal generally, starting in the morning, decreasing in the afternoon, and increasing again in the evening (Dahlan, 2015). Flying activity is needed by the wreathed hornbill to move towards food resources and nesting locations. The suitability of environmental factors such as wind velocity and appropriate light intensity can support the existence of the wreathed hornbill in Sokokembang Forest.

CONCLUSION

The population density of the wreathed hornbill in the Sokokembang Forest is 7.07 individuals/km^2. The characteristic of the wreathed hornbill habitat in Sokokembang Forest consists of a vegetation composition of 14 tree species from eight families. There are nine different types of fodder trees (foraging site), 10 types of perching trees (roasting site), and one species of nest tree (nesting site) which are utilized by the wreathed hornbill in Sokokembang Forest. Wind velocity and light intensity are environmental factors that have an influence on the density of wreathed hornbill in Sokokembang Forest.

The wreathed hornbill population in Sokokembang Forest must be protected by preserving the environmental and vegetative characteristics essential for their foraging, nesting, and roosting habitats. The results of this research can inform the conservation strategy of the wreathed hornbill in Sokokembang Forest.

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