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Cover Photograph: Displaying pair of Von der Decken's Hornbills. © Margaret F. Kinnaird

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Foreword

We are delighted and super pleased to announce the publication of the first issue of 'Hornbill Natural History and Conservation'. This is part of the work of the IUCN SSC Hornbill Specialist Group. We hope to bring out two issues of this online peer-reviewed publication annually which is free for access.

We hope this publication will highlight academic work, natural history notes, conservation stories and essays on hornbills of the world. While all research articles and notes will be peer-reviewed, this newsletter is also meant to share information/data/reports that often may not reach formal peer-reviewed journals.

In this first issue, a call for articles was announced in August 2019. The Editorial Board consists of Dr. Tim O'Brien, Dr. Divya Mudappa, Dr. T. R. Shankar Raman, and Dr. Jarryd Alexander who reviewed the submitted articles. They also edited the articles for clarity and Ms Janhavi Rajan formatted it for online publication.

The first issue has a good mix of papers from Asia and Africa. We have three main articles and four notes from the field with contributions from 26 authors. The 3 articles cover ecological work on several hornbill species in Sumatra and a study that addresses the question of genetic monogamy in two species of African hornbills. The notes cover interesting natural history observations from Brunei, China, Bhutan and South Africa. There are also updates and news of HSG activities and from the Helmeted Hornbill Working Group.

We are very grateful for the time and effort put in by our Editorial Board in bringing out the first issue of this IUCN SSC Hornbill Specialist Group's newsletter – Hornbill Natural History and Conservation. We hope that more HSG members and anyone working on hornbills will participate and contribute to this publication in future.

Wishing you all a great year ahead and one that is full of hornbills.

Aparajita Datta & Lucy Kemp

Co-Chairs, IUCN SSC Hornbill Specialist Group

Research articles

Hornbill density estimates and fruit availability in a lowland tropical rainforest site of Leuser Landscape, Indonesia: preliminary data towards long-term monitoring

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Abstract

Reliable density estimates of threatened species provide important information on their conservation status and effectiveness of conservation efforts. Here, we provided the first density estimates that utilize detection probability of four hornbill species in Ketambe Research Station area, Leuser Landscape. Moreover, we made a preliminary investigation of the relationship between hornbill detections and fruit availability. We conducted line transect and phenology surveys during July-September 2019. Our findings highlighted the importance of Ketambe as a stronghold for hornbill populations, indicated by relatively higher density estimates of four species (*Wreathed Hornbill* *Rhyticeros undulatus*, *Rhinoceros Hornbill* *Buceros rhinoceros*, *Bushy-crested Hornbill* *Anorrhinus galeritus*, and *White-crowned Hornbill* *Berenicornis comatus*) than elsewhere. We noted the lack of *Helmeted hornbill* detections which might be due to illegal poaching. Further, we identified the positive influence of ripe fruit supplies on hornbill presence. Our study presented the baseline density data for future hornbill population monitoring studies.

We also recommended conducting studies of hornbill diet and foraging behaviour and their responses to human disturbances.

Keywords: hornbill, population monitoring, food availability, detection probability, Leuser landscape

Introduction

Effective conservation strategies are necessary to halt and reverse the declining trends of biodiversity as a result of detrimental human activities (Butchart et al. 2010; Hoffmann et al. 2010). Population data such as density provides important information on the current conservation status of focus species or taxa (Marthy et al. 2016). Furthermore, this density baseline serves as starting point for wildlife monitoring to assess the rates of population change and to evaluate the effectiveness of conservation measures (Ariefiandy et al. 2013; Marthy et al. 2016).

Hornbills represent an ideal surrogate for population monitoring because of their ecological roles and conservation values. Hornbills are among the

most charismatic bird species in tropical rainforest (Kinnaird and O'Brien 2007). They act as indicators of forest condition and anthropogenic disturbance as hornbills require large and relatively-undisturbed forests with large and tall trees for feeding and nesting (Hadiprakarsa and Kinnaird 2004). Moreover, these species contribute in maintaining forests due to their ability to disperse fruit seeds over vast distances (Kitamura 2011).

Conservation of hornbills is especially relevant to the Island of Sumatra, which harbors nine out of the 13 hornbill species in Indonesia (Kinnaird and O'Brien 2007) where the threats to hornbills are pervasive. The Sumatran lowland tropical rainforest, the primary hornbill habitat is rapidly disappearing with 21.3% of the area being lost between 2000 – 2012 (Margo-no et al. 2014). This problem is exacerbated by the trading of hornbills for use as pets and ornaments (Beastall et al. 2016). These pressures were reflected in the hornbill IUCN Red List, where by the end of 2018, seven of the 13 hornbill species in Indonesia received an upgraded threatened status from either Least-Concern (LC) or Near-Threatened (NT) to Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) (IUCN 2019).

For three species, the changes were highly significant: Wrinkled Hornbill *Rhabdotorrhinus corrugatus* and White-crowned Hornbill *Berenicornis comatus* went from NT to EN, and Wreathed Hornbill *Rhyticeros undulatus* went from LC to VU. Furthermore, four other species were up-listed by one threatened status in 2018: Rhinoceros Hornbill *Buceros rhinoceros*, Great Hornbill *Buceros bicornis*, and Black Hornbill *Anthracoceros malayanus* from NT to VU and Bushy-crested Hornbill *Anorhynchus galeritus* from LC to NT. It should not be forgotten that the Helmeted Hornbill *Rhinoplax vigil* in 2015 made the most worrying jump from NT to CR, recognizing that it is on the edge of extinction.

Considering their threatened statuses, monitoring the population of these hornbills to understand their breeding success is crucial because it is the essence of their existence in the wild. However, hornbill population data from Sumatra is limited as only few studies have been published (e.g. Anggraini et al. 2000; Kinnaird and O'Brien 2007; Nur et al. 2013; Marthy et al. 2016; Kamal et al. 2018). Among these studies, only studies from Anggraini et al. (2000), Kinnaird and O'Brien (2007), and Marthy et al. (2016) had incorporated estimates of detectability to provide unbiased density estimates with comparable results over time and space (Karanth and Nichols 1998; Buckland et al. 2001).

In addition to hornbill population monitoring, assessment on the hornbill food sources is also important as a potential factor influencing the hornbill density. Anggarini et al. (2000) and Kinnaird and O'Brien (2007) suggested that hornbill densities in Sumatra and Sulawesi were significantly influenced by the type, amount, and ripeness of fruits available in their habitat. Hornbill densities can also highly fluctuate overtime in relation to fruit production, as reported by Kinnaird et al. (1996) who found Red-knobbed hornbill *Rhyticeros cassidix* monthly densities ranged from 9.30 – 82.7 individuals/km² during their two-year study at Tangkoko, Sulawesi. This density-fruit relationship thus emphasizes the importance of fruit availability—the principal hornbill diet—in assessing the hornbill population status.

Recalling the importance of providing reliable baseline data for long-term monitoring, this study aimed to: 1) estimate the baseline density of hornbill species accounting for detectability and 2) investigate the relationship between

hornbill detections and fruit availability in a monitoring site of the Leuser Landscape. We chose Leuser Landscape as it represents the largest extant Sumatran tropical forest (2.6 million ha) and is a global biodiversity hotspot with significant conservation focus, but is also increasingly threatened by infrastructure development, encroachment and other human activities (Sloan et al. 2018).

Method

Study Area

We conducted our study in Ketambe Research Station site (3°41'N, 97°39'E) within Gunung Leuser National Park (GLNP), part of Leuser Landscape, Sumatra (Hardus et al. 2012; Figure 1). Ketambe Research Station was established in 1971 and is widely known for its orangutan long-term studies. The site area (450 ha) is dominated by primary forest across elevation of 350 – 1 000 m a.s.l. (Wich et al. 1999). Approximately one fifth (83.1 ha) of the eastern part of Ketambe Research Station area is secondary forest as the result of selective logging in the early 2000's (Hardus et al. 2012). The site is located next to the boundary of GLNP, separated from nearby villages by the Alas River in the east.

We used five straight-line transects of 0.78 km (transect 1) and 1.50 km (transect 2-5) separated by 200 m. Transect 1 was shorter as it was located in the furthest north of the site area and limited by the site river boundary (Fig. 1). These transects were located to cover around 50% (220 ha) of the site area representing a mix of primary and secondary forests with an elevation between 400 – 600 m a.s.l. This area was chosen as it is the core area for ecological monitoring at the research station and has higher fruit production than the southern area (van Schaik and Mirmanto 1985; Wich et al. 2006). We did not allocate transects in the southern area (600 – 1 000 m a.s.l.) as it has rugged terrain and steep slopes, making straight line transect sampling difficult.

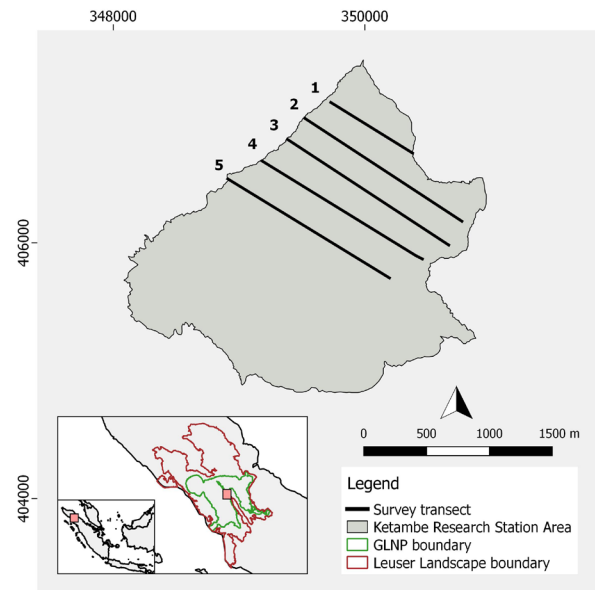


Fig. 1. Study area showing transects located in the core ecological monitoring area of Ketambe.

Hornbill population survey

We conducted variable-width line transect surveys for 2.5 months from July-September 2019 during dry (July-August) and wet (September) seasons (Thomas et al. 2010). The survey was conducted every two weeks, resulting in total of five replications. We started the survey from 07:30 – 10:30 (three hours). We surveyed one transect per day and used alternating transects separated by 400 m on the next day to minimize the chance of double counting (e.g. order of survey = transect 1, 3, 5, 2, 4). We also started from the opposite side of each transect for every other replication.

During the surveys, we collected data of 1) hornbill species, 2) detection type (visual or aural), 3) distance between observer and hornbill, 4) angle between observer position on transect and hornbill, and 5) number of individuals. Visual and aural signs were collected to increase the detection as visual encounter are often difficult in the primary forest with thick canopy cover and the data were combined for density estimates (Kinnaird et al. 1996;

Gale and Thongaree 2006; Marthy et al. 2016). Flying hornbills were recorded but not used for density analysis.

Fruit availability survey

We conducted the phenological surveys on the same day after the hornbill survey using the same transects (11:00 – 17:00), following the methods of Anggraini et al. (2000). We observed trees that produced fruits confirmed or potentially consumed by hornbills (e.g. fleshy fruits, drupaceous, and small-medium sized; Hadiprakarsa and Kinnaird 2004). All potential fruiting trees within 50 m of both sides of transects were mapped and identified to species or genus level. We visually estimated 1) the percentage of canopy covered by fruits (% fruit in canopy) and 2) the percentage of ripe fruits primarily based on changes of color due to ripeness (% ripe fruit). We also calculated the percentage of canopy covered by ripe fruits (% ripe in canopy = proportion of ripe fruit x proportion of fruit in canopy x 100). The identified tree species were then compared with the hornbill fruit diet list in Bukit Barisan Selatan National Park, Southern Sumatra (WCS-IP unpublished data) and supplemented with field observation to create a list of hornbill fruit diet in Ketambe.

Data analysis

We calculated the hornbill density estimates using Distance 7.3 (Thomas et al. 2010). A transect was assigned as the sampling unit and all hornbill detections per transect were compiled from five survey replications. The total survey effort was 33.9 km (total transects length of 6.78 km x 5 replications). We evaluated the uniform, half-normal, and hazard rate functions with key adjustments as suggested by Buckland et al. (2001) for each hornbill species. We right-trun-

cated the perpendicular distance data if natural breaks occurred to maintain the detection curve monotonicity. We then grouped the distance data based on the suggestion from automatically grouped detection curves provided by the aforementioned model outputs to improve the estimate precision.

To infer the density estimate of rare species with low detection ($N < 10$), we used a multi-species framework proposed by Alldredge et al. (2007). This framework was applied by “borrowing” the detection data of other species within the same genus or family with similar characteristics such as body size, diet, and calling (Alldredge et al. 2007; Marthy et al. 2016). For example, in this study we combined the detections of rare White-crowned hornbill ($N = 4$) with Bushy-crested Hornbill ($N=13$). Both have similar body size, fruit-animal diet, and live in groups (Kinnaird and O’Brien 2007). In the analysis, we calculated a combined detection probability for both species and post-stratified the density estimate by species (Marthy et al. 2016).

To examine the model goodness of fit, we used the Chi-square test. We selected the best fit model with the lowest Akaike’s Information Criterion (AIC) from the set of models (Buckland et al. 2001). If two or more models have similar AIC values ($\Delta AIC < 2$), we examined the detection curves, model fitness, and the percentage of coefficient of variation (% CV) of the density estimates. We selected the preferred model if the curve has continuous diagram with probability of detection near transect $g(0) \sim 1$, higher chi-square p-value, and lower % CV (Buckland 2006). Densities were presented as the number of birds per $\text{km}^2 \pm \% \text{CV}$.

To assess the relationship between hornbill detections and fruit availability, we used the

Table 1. Density estimates of four hornbill species in the lowland part of Ketambe Research Station site during July-September 2019 surveys.

Species	No. of detections	Average group size	Probability of detection	Density (ind/km ²)			
				Estimate	Lower 95% CI	Upper 95% CI	CV
Wreathed hornbill	86	2.00	0.31	39.26	25.68	60.01	19.10
Rhinoceros hornbill	37	1.38	0.69	3.05	1.30	7.11	34.10
Bushy-crested hornbill	13	7.26	0.54	6.06	2.37	15.51	38.80
White-crowned hornbill	4	3.50	0.43 ^a	0.51	0.12	2.20	67.46
Helmeted hornbill ^b	1	-	-	-	-	-	-

^aProbability of detection was combined with Bushy-crested hornbill.

^bInsufficient number of detections for density analysis.

negative binomial regression model that accounts for over-dispersed count data (Dobson and Barnett 2008). We assigned the number of hornbill detections per survey (detections) as the response variable. Relationships between explanatory variables were evaluated using correlation test with cut-off R value of 0.70 used in ecological studies (Mackenzie et al. 2006). Two final explanatory variables were used: 1) mean percentage of canopy covered by fruits (% fruit in canopy) and 2) mean percentage of canopy covered by ripe fruits (% ripe in canopy). Models were ranked using AIC and the best fit model was selected. We then identified the significant variables for hornbill detection based on the model output.

Results

Hornbill density estimates

We recorded a total of 141 detections of five hornbill species: Wreathed, Rhinoceros, Bushy-crested, White-crowned, and Helmeted hornbills. Aural detections accounted for 58% of total detections. We were able to estimate four species densities except for Helmeted hornbill that was only detected once (Table 1). The den-

sities ranged from 39.6 individuals (ind)/km² ± 19.1% for Wreathed hornbill to 0.51 ind/km² ± 67.46% for White-crowned hornbill. Overall, the analysis generated reasonably precise density estimates indicated by the CV < 40%. An exception occurred for White-crowned hornbill estimate, which has a high CV due to limited detections.

Relationship between fruit availability and hornbill detections

We recorded 166 observations of fruiting trees, consisting of 16 species within nine families during the survey (Appendix 1). A comparison between seven explanatory models showed that the model "Hornbill.detection ~ % ripe in canopy" was the best fit model with the lowest AIC (Table 2). We found that the mean percentage of canopy covered ripe fruits was a significant explanatory variable for hornbill detection (Table 3). Nevertheless, we acknowledged the possibility that not all fruit species consumed by hornbills in Ketambe were observed and verified. We also put caution on the limited sample size for replications (N = 5) when performing the analysis.

Discussion

Information on species population such as density estimate is not only important for the conservation managers to assess the species status in their area but also for assessment of their global conservation status (i.e. as in the IUCN species assessment). Here we presented the first density estimates of four hornbill species in Ketambe Research Station derived from sampling methods that utilized detection probability. As one of the last strongholds of tropical forests in Sumatra, the density estimates for these four hornbill species (Wreathed, Rhinoceros, Bushy-crested, and White-crowned hornbills) were relatively higher compared to other sites in Sumatra, Kalimantan, and Thailand (Table 4). We also found that the ripe fruit abundance had an influence on hornbill detection in the study area.

In our study site, the Wreathed Hornbill had the highest density estimates, approximately 5.23 times higher than density in South-west of Sumatra (Anggraini et al. 2000) and the highest from all hornbill population studies that utilized detection probabilities (McConkey and Chivers 2004; Gale and Thongaree 2006; Marthy et al. 2016). Kinnaird and O'Brien (2005, 2007) reported the influence of food availability on hornbill density, in which the birds follow the figs, a favorite dietary item of most hornbills. Here, the large number of Wreathed hornbills were related to the fruiting seasons of their favorite diet *Dysoxylum alliaceum* which occurred during the first three surveys of this study. From our observation, *Dysoxylum alliaceum* distribution is highly limited in Leuser Landscape and no documentation

Table 2. Top three negative binomial regression models ranked to assess the performance of food availability variables in explaining hornbill detections. Models incorporated percentage of canopy covered by ripe fruits (% ripe) performed better than other predictors.

Models	AIC	Δ AIC	Resid.df	2 x log-Likelihood
Hornbill.detection ~ % ripe in canopy	37.44	0	3	-31.44
Hornbill.detection ~ % ripe in canopy + % fruit in canopy	37.87	0.43	2	-29.87
Hornbill.detection ~ % fruit in canopy	41.06	3.62	3	-35.06

Table 3. Negative Binomial Regression Model describing explanatory variables of hornbill detection based on the top model. Back transformed coefficients (β) and confidence interval (CI) represents the strength and direction of influence. Significant variables (p-value < 0.05) are highlighted in bold.

Explanatory variable of hornbill detection	β	95% CI	z value	p value
Intercept	7.73	3.14-18.20	4.57	0.000
% ripe in canopy	1.07	1.03-1.13	3.02	0.003

Table 4. Density estimates (individuals/km² with 95% CI) of hornbill species from this study compared to other studies accounted for detectability.

Species	This study	South-west Sumatra (Anggraini et al. 2000)	South-central Sumatra (Marthy et al. 2016)	Central Kalimantan ^b (McConkey and Chivers 2004)	Southern Thailand (Gale et al. 2006)	Ketambe ^c (Van Schaik et al. 1992)
Wreathed hornbill	39.26 (25.68-60.01)	7.50 ^a	+	0.10	0.69 (0.40-1.18)	4.12 (1.19)
Rhinoceros hornbill	3.05 (1.30-7.11)	2.60	1.20 (0.70-2.10)	3.70 (2.50-4.90)	2.69 (1.99-3.64)	2.39 (0.91)
Bushy-crested hornbill	6.06 (2.37-15.51)	3.05	4.60 (1.70-12.20)	5.50	0.64 (0.32-1.28)	4.89 (3.06)
White-crowned hornbill	0.51 (0.12-2.20)	+	+	0.30	0.08 (0.03-0.24)	-
Helmeted hornbill	+	1.90	0.40 (0.20-0.70)	0.70	1.21 (0.81-1.82)	0.42 (0.20)

+ Species present

- Species absent

^aDensity estimate calculated from Distance but without information on CI.

^bDensity for Rhinoceros hornbill was calculated from distance sampling; other species were estimated from strip transects

^cUsed multiple triangulation method in January 1992; density estimates were presented with standard deviation (SD).

has been recorded in other locations outside Ketambe yet.

The detections of Wreathed hornbill were decreased in last two surveys, potentially because they were foraging on fruits outside the study area, as Wreathed hornbill have large home range up to 2400 ha (Kitamura 2011).

The density of Rhinoceros hornbill was also higher than in other studies. As this species is highly frugivorous and favored figs (Hadiprakarsa and Kinnaird 2004; Kitamura 2011), the numerous fig trees in Ketambe provide abundant food supplies. Furthermore, Hadiprakarsa and Kinnaird (2004) observed similar diet preferences between Rhinoceros and

Helmeted hornbills which could lead to competition between these two species. Helmeted hornbills are rarely present in Ketambe; thus, we expect Rhinoceros hornbills to dominate food sources and result in higher density.

Bushy-crested hornbill density was also considerably higher in Ketambe. This species strongly avoids disturbed areas and prefer closed-canopy forest (Anggraini et al. 2000). As Ketambe is surrounded by human settlements and plantations in the eastern side, our study site represents an ideal habitat for this species. However, we also observed Bushy-crested hornbills in our secondary forest site next to the Alas River. This observation indicated that Bushy-Crested might not be as highly sensitive to disturbed areas as previously reported.

This study also provides the density of rare White-crowned hornbill, the first in Sumatra. This omnivorous species has a substantial meat diet but limited information of its fruit-meat diet has been published (Kinnaird and O'Brien 2007; Kitamura 2011). Thus, their density might be influenced by not only fruit supplies, but also small animals and insects, requiring further assessments. It is worth noting that White-crowned hornbill density was generated through the multi-species framework in Distance (Allredge et al. 2007), which can be useful in estimating density of rare species in future studies.

While there is no estimate for Helmeted hornbill density in Ketambe, the single aural detection indicated a much lower density compared to other studies. The scarcity of Helmeted hornbill detection might have resulted from illegal poaching in Ketambe that started in the early 2010s due to rapid demand of the hornbill casques (Beastall et al. 2016). Since 2011, the research and patrol activities within Ketambe Research Station were interrupted until 2015, thus routine protections were absent during that period. The population decrease was confirmed by van Schaik's study (cited from Kinnaird et al. 1996) that reported higher density of this species in Ketambe three decades ago (0.42 ind/km²), although differences in survey method and analysis were acknowledged. This decrease was also reported by local research staff including authors MI, ARW, and IBR who frequently encountered Helmeted hornbills in 1990's and 2000's. We suggested poaching as the main factor for low detection of Helmeted hornbill in the study area as there was no notable habitat loss or disruption in Ketambe and the fruiting trees, especially figs, were still present in large numbers.

Previous study in Ketambe site by van Schaik in 1992 (cited from Kinnaird et al. 1996) report-

ed the presence of Wrinkled hornbill and Black hornbill. Great hornbills are present in forests around Ketambe and usually are found together with a flock of Rhinoceros hornbills in fruiting trees (ARW and MI, personal observation). However, these three species were not detected in this survey. We have limited knowledge of the absence of Great, Wrinkled, and Black hornbills. Without ruling out the possibility of poaching, we suspect the competition with abundant closely-related species like Wreathed and Wrinkled or Rhinoceros and Great hornbills might contribute to this lack of detection which requires further investigation.

Previous studies reported the increase of hornbill abundance in relation to fruit availability (Kinnaird et al. 1996; Anggraini et al. 2000; Naniwadekar et al. 2015). This study found that overall hornbill detections were positively correlated with the percentage of ripe fruits in the canopy. Our findings confirmed the importance of ripe fruits reported by Anggraini et al. (2000), as we observed hornbills were attracted to the trees with abundant ripe fruits. The ripe fruits provide more sugar and nutrients than unripe fruits, thus they are preferred by hornbills (Hadiprakarsa and Kinnaird 2004; Kitamura 2011). A notable observation of this relationship was the Wreathed hornbill in Ketambe. Their detections were significantly lower in the last two surveys because there were no ripe fruits of *Dysoxylum alliaceum* present.

Implications for hornbill conservation management

Our study provides reliable baseline density data of four hornbill species in Ketambe Research Station, Leuser Landscape. The findings confirm the importance of Ketambe for hornbill conservation indicated by overall species higher densities, especially Wreathed hornbills which

to our knowledge is the highest ever documented from studies utilized detection probabilities (Table 4). Future research is needed to better understand the population and ecology of hornbills in the Leuser Landscape. Firstly, as hornbill densities fluctuate over time in relation to fruit supplies, long term monitoring (e.g. monthly and yearly) is needed to identify the population dynamics. Secondly, as the current study only cover a small portion of the Leuser Landscape, we suggested conducting population surveys in additional sites in this landscape. Thirdly, hornbill foraging behavioral studies are needed to identify the species and characteristics of fruits and animals consumed by hornbills. Finally, as Ketambe is located next to human settlements, comparative studies of hornbill densities between pristine, edge, and disturbed habitats could provide important information on hornbill responses to disturbances.

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Appendix 1. Summary of observed fruiting trees categorized by family.

Family	Species	No. of observation
Annonaceae	<i>Canarium odorata</i>	12
Clusiaceae	<i>Garcinia dioica</i>	6
Combretaceae	<i>Terminalia bellirica</i>	6
Elaeocarpaceae	<i>Elaeocarpus petiolatus</i>	3
Euphorbiaceae	<i>Sapium baccatum</i>	1
Meliaceae	<i>Dysoxylum alliaceum</i>	98
Moraceae	<i>Antiaris toxicaria</i>	1
	<i>Ficus altissima</i>	5
	<i>Ficus annulata</i>	1
	<i>Ficus benjamina</i>	2
	<i>Ficus drupacea</i>	2
	<i>Ficus obscura</i>	8
	<i>Ficus parietalis</i>	1
	<i>Ficus</i> sp.	8
Myristicaceae	<i>Knema laurina</i>	11
Sapindaceae	<i>Pometia pinnata</i>	1

Genetic monogamy in Von der Decken's and Northern Red-billed hornbills

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Abstract

Avian monogamy is usually characterized by social monogamy, a cooperative pair bond rather than genetic monogamy, a pair bond accompanied by fidelity. Hornbills (*Bucerotidae*, *Bucorvidae*) have a range of monogamous social systems, but only one species, Monteiro's hornbill (*Tockus monteiri*) has been confirmed to be genetically monogamous. We examined paternity patterns for two *Tockus* species, Northern Red-billed hornbill (*T. erythrorhynchus*) and Von der Decken's hornbill (*T. deckeni*). We collected blood from females and chicks in nestboxes, and the putative father delivering food to the nestbox, or accompanying juvenile birds. Paternity was determined using a double-digest restriction site-associated DNA sequencing (ddRAD-seq). All males delivering food for both species ($n = 35$ males). For males accompanying juveniles, 14 of 15 putative fathers were identified as the genetic father. Our results extend the occurrence of genetic monogamy to three species of *Tockus* hornbills.

Keywords: genetic monogamy, *Tockus* hornbills, pair bonds, fidelity

Introduction

Avian monogamy has been a topic of interest for many decades (Lack 1968). However, only recently has social monogamy been distinguished from genetic monogamy. Social monogamy (85% of bird species) is defined as an exclusive living arrangement involving a

pair bond between a male and female, often characterized by cooperation in resource acquisition and parental care (Bennett and Owens 2002). Genetic monogamy is defined as an exclusive pair bond accompanied by exclusive parentage or fidelity (Gowaty 1996, Reichard 2003). Social and genetic monogamy are not always equivalent; on average, 12.5% of offspring of socially monogamous species result from extra-pair copulations (Bennett and Owen 2002).

Asian hornbill species exhibit four monogamous social systems including nomadic pairs, part-time territorial pairs, year-round territorial pairs, and territorial family groups (Kinnaird and O'Brien 2007). Among African hornbills, savanna species including ground-hornbills (*Bucorvus* spp.) and *Tockus* hornbills (*Tockus* spp.) are the best studied (Kemp 1995). Ground-hornbills are cooperative breeders on large territories and savanna *Tockus* hornbills are monogamous pairs on part-time or year-round territories.

Only one study has been published on genetic monogamy in a hornbill species, Monteiro's Hornbill (*Tockus monteiri*) in Namibia (Stanback et al. 2002), where blood was obtained from 38 hornbill families including 138 chicks. No evi-

dence of extra-pair copulations was found and all chicks were assigned to their putative father. In this paper, we report on the results of a paternity analysis of chicks of two African savanna hornbill species, Von der Decken's hornbill (*T. deckeni*) and Northern Red-billed hornbill (*T. erythrorhynchus*) in northern Kenya.

Methods

This project was conducted at the Mpala Ranch and Research Center, Laikipia County, Kenya (0.284 – 0.5248 N and 36.828 – 36.8838 E). Mpala Ranch is a 200 km² cattle ranch and wildlife conservancy. Topographically, Mpala Ranch consists of rolling hills, an uplifted plateau, granitic inselbergs, and is bordered by rivers along more than half of its boundary. Annual rainfall averages 594 mm in the south and 430 mm in the north, with rains typically occurring during April-May and October-November. Droughts are sporadic, but increasing in frequency (Franz 2007). The landscape is covered by bushland dominated by *Acacia mellifera*, *A. etbaica*, *A. brevispica*, and *Grewia tenax*, and by *A. drepanolobium* open woodland. Hornbill species observed on the ranch include Eastern yellow-billed (*T. flavirostris*), Crowned (*T. alboterminatus*), Northern red-billed (*T. erythrorhynchus*), Von der Decken's (*T. deckeni*), African grey (*T. nasutus*) and Silvery-cheeked hornbills (*Bycanistes brevis*). Only Von der Decken's and Northern red-billed hornbills have been observed to breed on Mpala.

We used three strategies to capture hornbills. First, we used walk-in traps, baited with peanuts and set around the Mpala Research Center from 2011 to 2015. Second, we deployed 90 nest boxes during the breeding seasons of March – July 2012 through 2015. Boxes were 25 x 20 x 50 cm with a 6 cm diameter entrance, a perch below the hole, and a lockable side

door for examining the female and chicks (Fig. 1). Boxes were placed in trees or on 4 m poles along service roads. Boxes were examined every 4 days. Blood samples were obtained from females in nestboxes after chicks were hatched, and from chicks 2 weeks after hatching. Finally, males delivering food to nest boxes were captured using mist nets placed in front of nest boxes and using recorded male hornbill calls as an audio lure. All hornbills were tagged with a National Museums of Kenya metal identification leg band and colored plastic leg bands.

Genetic analysis was conducted at the Cornell Laboratory of Ornithology to identify the genetic parentage of chicks. They used a double-digest restriction site-associated DNA sequencing (ddRAD-seq; Puritz et al. 2014) analysis. This approach simultaneously locates single nucleotide polymorphisms (SNP) and genotyping steps and is optimized to return a statistically powerful set of SNP markers (typically 150-600 after stringent filtering) from large numbers of individuals (up to 240 per run). For full details of the analysis, see Thrasher et al. (2017).

Results

We monitored 10 Northern red-billed hornbill (NRBH) successful nesting events in 2012 ($n = 2$), 2013 ($n = 3$), and 2015 ($n = 5$) involving nine females and 19 chicks, and captured four young juvenile birds with putative fathers in walk-in traps. For Von der Decken's hornbills (VDDH), we monitored 27 successful nesting events in 2012 ($n = 2$), 2013 ($n = 9$), 2014 ($n = 6$) and 2015 ($n = 10$) involving 26 females and 40 chicks, and 11 capture events involving young juveniles traveling with an adult. For chicks banded and bled at the nest site, we had 100% assignment of social father to genetic father for both species. For four cases of juvenile NRBH captured with an associated adult male, in all



Fig. 1. Male Von der Decken's hornbill delivering a beetle to female in nestbox.

cases, the adult male was the genetic father. For 11 cases of juvenile VDDH captured with an associated adult male, in 10 of 11 cases, the male was identified as the genetic father.

Discussion

Our results extend the finding of genetic monogamy in Montiero's hornbill (Stanbeck et al. 2002) to two additional *Tockus* species, Northern red-billed and Von der Decken's hornbills. *Tockus* hornbills exhibit several characteristics of long-term monogamy including year-long associations, territoriality, courtship feeding and sperm storage. Mulder et al. (1994) argued that any tendency toward extra pair copulations in birds would be a compromise between females seeking genetically superior males and her dependence on male provisioning during nesting. Gowaty (1996) also believed that the female should always seek a genetically superior male and that socially bonded males should attempt to restrict access to females through mate guarding or other constraints. Gowaty

believed that the threat of withholding food from females was sufficient to constrain her, since female *Tockus* hornbills generally molt tail and wing feathers during incubation and are unable to fly, and male desertion would doom the female and her chicks. Such conflict-mediated reproductive strategies assume that costs incurred are tolerable for (at least) one sex and that one sex gains at a cost to the other (Mock and Forbes 1992).

Stanbeck et al. (2002) note that mate guarding is not particularly strong in Montiero's hornbills and Finnie (2012) found the same in Southern yellow-billed hornbills (*T. leucomelas*). This loose guarding, combined with sperm storage, allows for the possibility of extra-pair copulations prior to entering the nest. Purple Sandpipers (*Calidris maritima*) are long-lived, socially monogamous sandpipers also characterized by strong mate and territory fidelity, high male parental investment and loose mate guarding, that rarely seek extra-pair copulations (Pierce

and Lifjeld 1998). Both Stanback et al (2002) and Pierce and Lifjeld (1998) argue that, when male paternal investment is high, the females have little to gain from extra-pair copulations and should resist extra-pair copulations, making male attempts energetically expensive. Stanback et al. (2002) also argue that the complete dependence of female and chicks on male provisioning results in a strong overlap in reproductive interests of males and females, resulting in cooperation rather than conflict.

For seven females (NRBH = 1 and VDDH = 6) that nested at least twice during our study, we found that the same male was the father after two to four years, indicating extended pair bonds in both *Tockus* species. Based on the observation of extended pair bonds in hornbills, overlap in reproductive interest, and high male parental investment, we agreed with Stanback et al. (2002) that mate choice by females is based on provisioning skills rather than phenotypically expressed genetic superiority (Kinnaird and O'Brien, 2008). Females should try to retain a good male provider. Since male provision is equal to female reproductive success, and inferior male providers will either kill the female and chicks or force the female to abandon the chicks, females should only engage with untested males under three conditions; a female mating for the first time, a female who has abandoned an inferior male provider, or a female who has lost a mate. Females abandoning inferior males may be a common feature in monogamous systems with extended pair bonds where females use paternal investment as a signal of male quality.

A distinction between our ideas and those of Stanback et al. (2002) is the order of events in the development of monogamy in hornbills. Stanback et al. (2002) assume that nest-sealing

evolved as an anti-predator behavior which in turn led to long-term sperm storage, high male investment, and cooperation over conflict. We argue that if nest sealing was an effective anti-predator behavior, it should have evolved more often among cavity nesters (Kinnaird and O'Brien, 2008). Although hornbills have higher nesting success than other cavity nesting species, the result is not significantly different. We believe that female nest sealing evolved as a female strategy to ensure the cooperation of the male.

Our study strengthens the argument that *Tockus* hornbills are genetically monogamous as well as socially monogamous. It also leads us to question whether the pattern of genetic monogamy will hold for Asian hornbills and the forest hornbills of Africa. Given the increasing use of nest boxes to augment hornbill nesting, there is a greater opportunity to test for paternity within other hornbill genera.

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Long-term monitoring of nesting behavior and nesting habitat of four sympatric hornbill species in a Sumatran lowland tropical rainforest of Bukit Barisan Selatan National Park

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Abstract

Hornbills are vulnerable to extinction due to their low reproductive output and dependence on large trees as nesting sites. However, little is known about their breeding behavior in Sumatra, which is important to plan effective strategies to save the nine species from extinction. Here we present the nesting season and nest-site characteristics of sympatric hornbills at Way Canguk Research Station, Bukit Barisan Selatan National Park, Sumatra, Indonesia. We monitored in total 35 tree cavities in two monitoring periods: 23 tree cavities between 2006 – 2009 and 20 between 2015 – 2018; and recorded the nesting activities of hornbills. We also measured the characteristics of nest trees, nest cavities, and vegetation within 20-m radius of the nest trees. We found that there was a significant decrease of nesting frequency between the two monitoring periods, from a mean of 0.058 records/year in 2006 – 2009 to 0.013 records/year in 2015 – 2018. Of eight hornbill species known to occur in the study area, only four were found nesting during the study periods, i.e. Bushy-crested, Helmeted, Rhinoceros, and Wreathed Hornbills. Among the four species, there were no differences in the height of nest cavities, diameter, and height of nest trees. All species preferred emergent trees and trees with big trunks as nesting sites. Wreathed Hornbill preferred nests with more vertically-elongated nest entrance compared to the other three species which were found nesting in oval cavities. Bushy-crested Hornbill seemed

to select nest cavities with entrance facing toward north-east direction, while the other hornbill species did not have preferences. Most tree species that were used by hornbills for nesting also have high timber value, thus are vulnerable to the risk of illegal logging. To ensure the survival of hornbills, sufficient number of tree cavities that are suitable for nesting must be maintained.

Keywords: breeding, bird population, reproductive behaviour, Way Canguk Research Station

Introduction

Ensuring the success of a species' reproduction is important to safeguard the survival of the species. Understanding species' reproductive behavior and breeding habitat suitability are required to plan effective conservation actions (Côté 2003). Hornbills are cavity-nesters that are dependent on the availability of tree cavities for breeding. They are, however, unable to excavate their own nesting cavities (Poonswad 1995), but rather occupy cavities formed by the decay of broken branches or excavated by other birds such as woodpeckers and barbets (Datta and Rawat 2004, Supa-Amornkul et al. 2011).

Hornbills' nesting cavities are usually located in large and tall trees (Poonswad 1995, Mudappa and Kannan 1997, Utoyo et al. 2017), which are rare in logged forests because the trees with such characteristics are also of high timber value (Mudappa and Kannan 1997, Collar 2015).

Hornbills occur sympatrically with a number of other hornbill species across their ranges. As frugivores and cavity-nesters, they have overlapping niche, but some sympatric hornbills also exhibit resource partitioning on foraging strategies and nest cavity preferences. In Sumatra, Helmeted hornbill *Rhinoplax vigil* and Rhinoceros hornbill *Buceros rhinoceros* tend to predominantly feed on figs, while the diet of Bushy-crested hornbill *Anorrhinus galeritus* and Wreathed hornbill *Rhyticeros undulatus* primarily consists of oily drupaceous fruits (Hadiprakarsa and Kinnaird 2004). Helmeted hornbills are found more frequently in the upper canopy relative to the other sympatric species (Hadiprakarsa and Kinnaird 2004). Great hornbill *Buceros bicornis* tend to use larger cavities, while Oriental Pied hornbill *Anthracoceros albirostris* used smaller ones in India (Datta and Rawat 2004). Poonswad (1995) also reported differences in nesting tree diameter, tree height, and nest cavity dimensions among four sympatric hornbills in Thailand.

Compared to the other forest birds, hornbills have distinctively larger body size which is linked to lower reproductive output, longer generation spans, and dependence on large tree cavities (Gonzalez et al. 2013). Therefore, it will take a long time to reverse population declines. Unfortunately, hornbills face high threats of extinction due to habitat loss, habitat disturbance, forest fragmentation, and illegal hunting (Kinnaird and O'Brien 2007). Forest fires are known to be associated with the de-

cline of nesting success in hornbill population (Cahill and Walker 2000) and the population decline of some hornbill species (Anggraini et al. 2000). Helmeted Hornbill is highly hunted for their dense casques that are used for carving—around 2,170 casques were seized from illegal market in Indonesia and China between 2012 and 2014 (Beastall et al. 2016).

The island of Sumatra harbors nine species of hornbills among the 62 hornbill species found globally and among the 13 species found in the Indonesian archipelago. Of the nine species, one is listed as Critically Endangered, two as Endangered, and four as Vulnerable on the *IUCN Red List of Threatened Species* (IUCN 2019). There are only few studies on hornbill nesting behavior in Indonesia (Marsden and Jones 1997, Kinnaird and O'Brien 2007, Rahayuningsih et al. 2017). Particularly, not much is known about hornbill nesting cycle and nesting site characteristics in Sumatra. In this study, we aimed to (1) estimate the nesting period of four sympatric hornbills, and (2) assess the characteristics of the hornbills' nest cavities, nest trees, and nest sites at Way Canguk Research Station (WCRS), one of the last Sumatran lowland rainforests.

Methods

Study area

We conducted long-term tree cavity monitoring at Way Canguk Research Station (WCRS), Bukit Barisan Selatan National Park (BBSNP), Lampung Province, Sumatra, Indonesia (Fig. 1). The research area covers 800 ha of lowland dipterocarp forest which ranges between 15 – 70 m above sea level. The forest is a mixture of intact primary forest and secondary forest disturbed by past forest fires and illegal logging. The annual rainfall during the study periods (2006 to 2018) ranged between 2459 – 4620

mm, with a mean of 3347 ($SD = 644$) mm. The research area experiences two seasons: dry season during March-September (driest month in August with a mean rainfall of 91 mm/month) and rainy season during October-April (wettest month in November with a mean rainfall of 519 mm/month). Eight hornbill species have been recorded in the research area: Black hornbill *Anthracoceros malayanus*, Bushy-crested hornbill, Great hornbill, Helmeted hornbill, Oriental Pied hornbill, Rhinoceros hornbill, White-crowned hornbill *Berenicornis comatus*, and Wreathed hornbill.

Tree cavity monitoring

We recorded the locations of trees with cavities found within the 800 ha research area *ad libitum* during other biodiversity monitoring or research. Each month throughout the year since 2006, we monitored the tree cavities and recorded the occurrence of nesting hornbills. If there were hornbills nesting in a tree cavity, we monitored their activities for three days each month (average interval between visits = 7 days, $SD = 6.9$), 4 – 5 hours per day. We recorded their behavior *ad libitum* and we tried to minimize disturbance by frequent visit as these hornbills are really sensitive (based on our field observation where once they noticed human presence the female will alert the male to not approach the nest).

The monitoring data were only available for 2006 – 2009 and 2015 – 2018. We calculated hornbill nesting frequency (f) during each period using the following formula:

$$f = \frac{\text{number of nesting hornbill}}{\text{monitoring effort}(\text{year})}$$

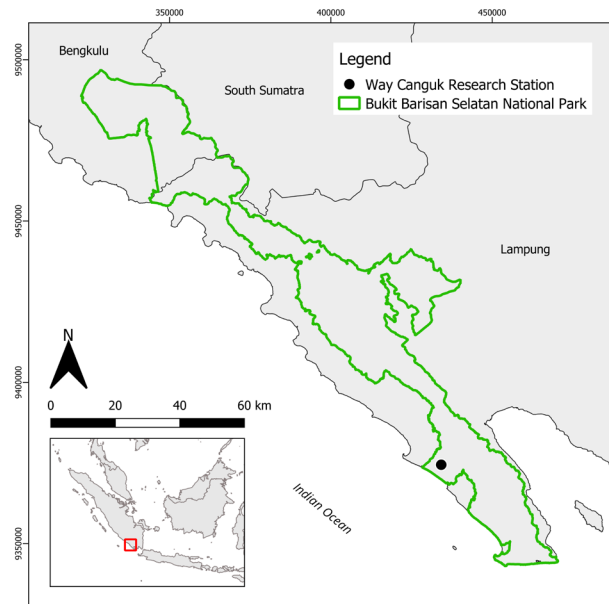


Fig. 1. The location of Way Canguk Research Station in Bukit Barisan Selatan National Park, Sumatra, Indonesia.

We calculated nesting frequencies for each individual tree. To account for unequal monitoring effort for each tree (Fig. 2), we included monitoring effort in the calculation instead of simple counts of nest records. A record of hornbill occupying a cavity was included in the calculation if the hornbills were seen occupying the cavity for a minimum of 2 survey-months. Survey effort was defined as the number of survey-months, and then converted to years. We only calculated nesting frequencies in trees that we monitored for a minimum 24 months in each study period. We then tested for differences between the nesting frequencies in 2006 – 2009 and 2015 – 2018 using Wilcoxon rank sum test.

The duration of nesting cycle was approximated by calculating the difference between the first and last date when the hornbills were observed to occupy the cavity. To estimate the nesting duration, we only used the observation data if we had checked the cavity at least a month before and after the hornbills nesting to allow a more accurate estimation.

Nesting cavity characteristics

We measured the nest tree and cavity characteristics of nests used by any hornbill species. We measured 1) the nesting tree's diameter at breast height (dbh) using a diameter tape at 1.3 m above ground; 2) tree height, nest height from the ground, and height of first branch using a range-finder; 3) and nest entrance orientation relative to compass direction. We also climbed the tree and measured the height and width of the cavity opening. Nest entrance measurements were made when the hornbills were no longer occupying the tree cavity.

We then performed Kruskal-Wallis test for testing the differences in nesting tree diameter, tree height, nest cavity height, and nest opening height:width ratio among the four hornbill species. If we found a statistically significant result ($p < 0.05$), we further ran Dunn's multiple comparison test as a post hoc test to determine species pairs that exhibited significant differences. Orientation angles of nest entrances were treated as circular data. We ran Rayleigh test for circular data for each species separately to examine if the nest entrances for each hornbill species faced random direction (null hypothesis) or faced particular direction (alternative hypothesis; Landler et al. 2018).

Vegetation survey

We surveyed the vegetation surrounding the nesting tree within circular sampling plots of radius 20 m with the nesting tree at the center. We recorded all plants with a dbh ≥ 10 cm. We identified the trees to species level (identification guide: Whitmore 1972) and measured the dbh, tree height, and height of the first branch. We ran Wilcoxon rank sum test to see the differences between 1) nesting tree dbh and the dbh of surrounding trees, and 2) nesting tree height and surrounding tree height.

To describe the vegetation community in nesting sites, we calculated Shannon diversity index, species richness, and tree density in each sampling plot. We then performed Kruskal-Wallis test and Dunn's test to examine differences in vegetation characteristics between nesting sites of the four hornbill species.

Results

Nesting frequency and duration

We monitored 23 tree cavities in 2006 – 2009 and 20 trees in 2015 – 2018 (totaling 35 tree cavities). Among these, 8 trees were monitored in both periods and there were 12 new trees in 2015 – 2018. Fifteen trees found in 2006 – 2009 were no longer monitored because either the trees fell down or the cavities shrank. Of 8 hornbill species known to occur in WCRS, we recorded four species nesting during 2006 – 2018 in 19 tree cavities across the study area (Fig. 2). Between 2006 and 2009, we recorded 19 occurrences of nesting hornbills (mean $f = 0.058$ records/year, $SD = 0.037$), and between 2015 and 2018, there were 10 records (mean $f = 0.013$ records/year, $SD = 0.012$). There was a significant decrease of nesting frequencies between period 2006 – 2009 and 2015 – 2018 (Wilcoxon test, $W = 81$, $p < 0.001$).

Five of 19 nest cavities were used by hornbills multiple times, and the same cavities tended to be re-occupied by the same hornbill species. For example, a cavity in a *Terminalia bellirica* was used four times by the Wreathed Hornbill (three times between 2006 – 2009 and once in 2015). An exception was recorded in 2009 when a nesting pair of Wreathed hornbills in a *Dipterocarpus humeratus* were replaced by Helmeted hornbills. Unfortunately, the tree had fallen down before 2015, so we could not perform nest measurement.

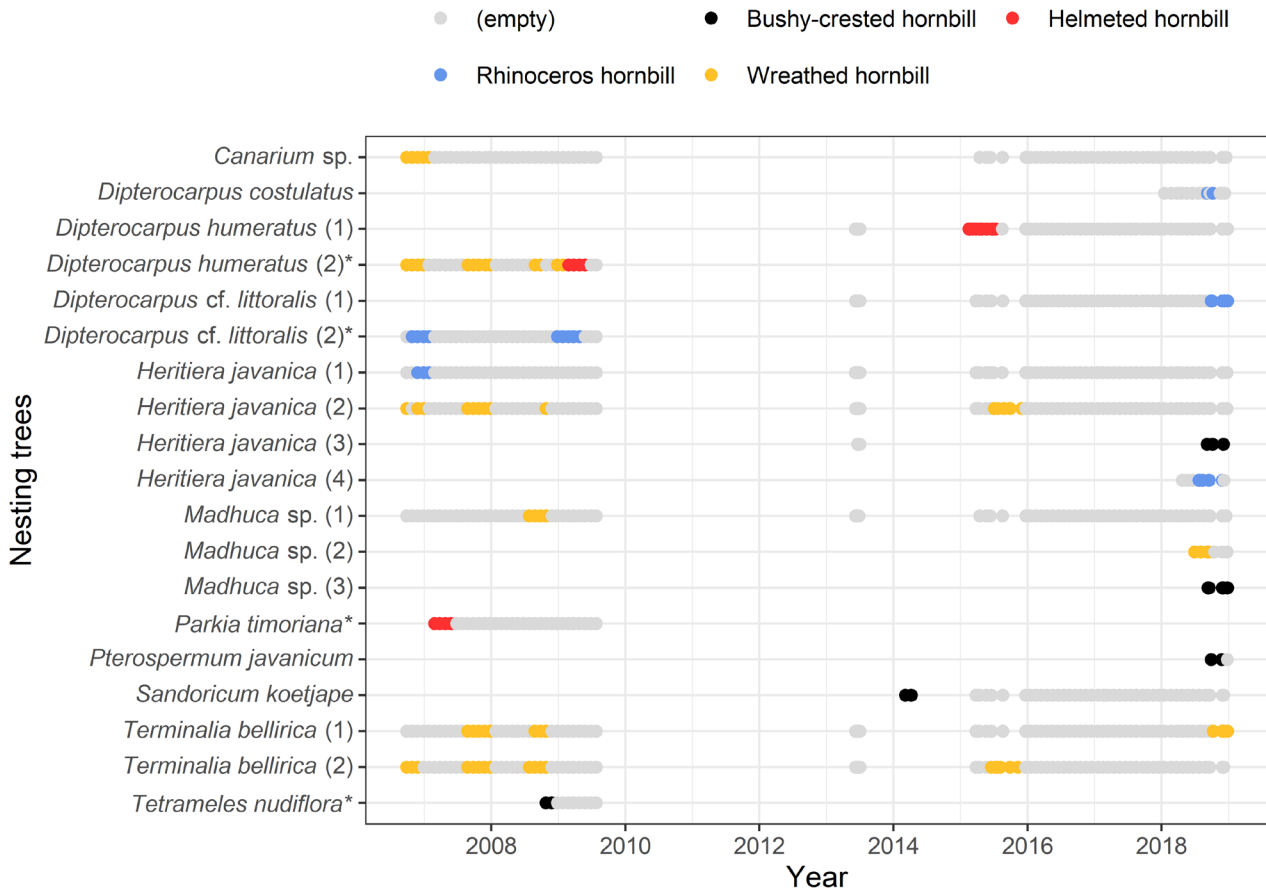


Fig. 2. Nesting cycle of hornbills at Way Canguk Research Station. Tree species with asterisks had fallen down or the cavities were damaged/closed.

Of four hornbill species, nesting period could only be estimated for three species, i.e., the Rhinoceros, Helmeted, and Wreathed hornbills. Of a total of 29 nesting records, we could not estimate the nesting duration on seven records because the cavities were found when the hornbills had already started nesting. All observations of nesting Bushy-crested Hornbill were encountered after they started nesting. Hornbill, Rhinoceros Hornbill exhibited longer nesting durations (Table 1).

In general, Rhinoceros Hornbill started nesting in mid-year and left the nest at the end of the same year or early the next year. Among the four species, Wreathed Hornbill was the most frequently found nesting in the study area. This species usually started nesting between July-August, and then left the nest between October-Decem-

ber. Helmeted Hornbill was recorded nesting in early year (Jan-Feb), and left the nest around midyear. There was no record of the time when Bushy-Crested Hornbill start nesting, but we recorded two occurrences of them leaving the nest in December (Fig. 2).

Other than the 10 records of nesting Wreathed Hornbills, we also twice recorded Wreathed Hornbills visiting tree cavities for approximately 31 days in August-September 2008 and December 2008-January 2009. Subsequently in February 2009, however, the cavity was occupied by a pair of Helmeted hornbills. Other competition events for tree cavities were also recorded on 16 January 2016 and 26 April 2018. On the former date, a pair of Rhinoceros Hornbills was

Table 1. Nest duration approximation

Species	No. of nesting records	Mean (SD) of nesting duration in days	Range in days	Range in days based on previous studies
Rhinoceros hornbill	5	99 (26)	62 – 127	80 – 143 ^a 50 – 111 ^b
Helmeted hornbill	2	118 (40)	89 – 146	172 ^a 140 – 162 ^b 154 – 167 ^c
Wreathed hornbill	10	116 (27)	61 – 149	128 ^a
Bushy-crested hornbill	5	-	-	90 ^a

^aKinnaird and O'Brien 2007

^bKaur et al. 2015

^cChong 2011

observed visiting a tree cavity, but in the next survey-month, a flying squirrel *Petaurista* sp. was seen inside the cavity. In April 2018, a female Wreathed Hornbill entered a tree cavity for two days, but was then disturbed by a pair of Rhinoceros hornbills on the third day. The Wreathed hornbill left the nest subsequently and the cavity was occupied by a pair of Rhinoceros hornbills on 23 July 2018.

Nest cavity and nest site characteristics

Of a total of 20 trees that were monitored during 2015 – 2018, tree and cavity measurements were made only on the 16 occupied nest trees (Appendix 1). The tree cavities occupied by hornbills were at minimum 16.5 m above ground (mean nest height = 31.9 m, *SD* = 9.3 m). Most of the nest cavities (67%) were located higher than the first branch of the trees. In general, the nesting trees were characterized by large trunk size (dbh

range = 56.5 – 185.0 cm, mean = 104.3 cm, *SD* = 37.9 cm) and tall trees (range height = 35.0 – 61.1 m, mean = 47.7 m, *SD* = 7.4 m). We found no evidence of differences in nest cavity height (Kruskal-Wallis test, *N* = 16, *df* = 3, *H* = 5.78, *p* = 0.12), tree diameter (*H* = 5.71, *p* = 0.13), and tree height (*H* = 3.64, *p* = 0.30) used by the four hornbill species.

All nesting trees were emergent trees relative to the surrounding trees (Fig. 3) and were significantly taller than the other trees (Wilcoxon test, *W* = 161, *p* < 0.001). The diameter of nesting trees were also significantly higher than the other trees within the 20-m circular plots (Wilcoxon test, *W* = 228.5, *p* < 0.001).

Of the four hornbills, the size of nesting cavity entrance of Helmeted hornbill was the largest, while the smallest was the Bushy-crested Hornbill

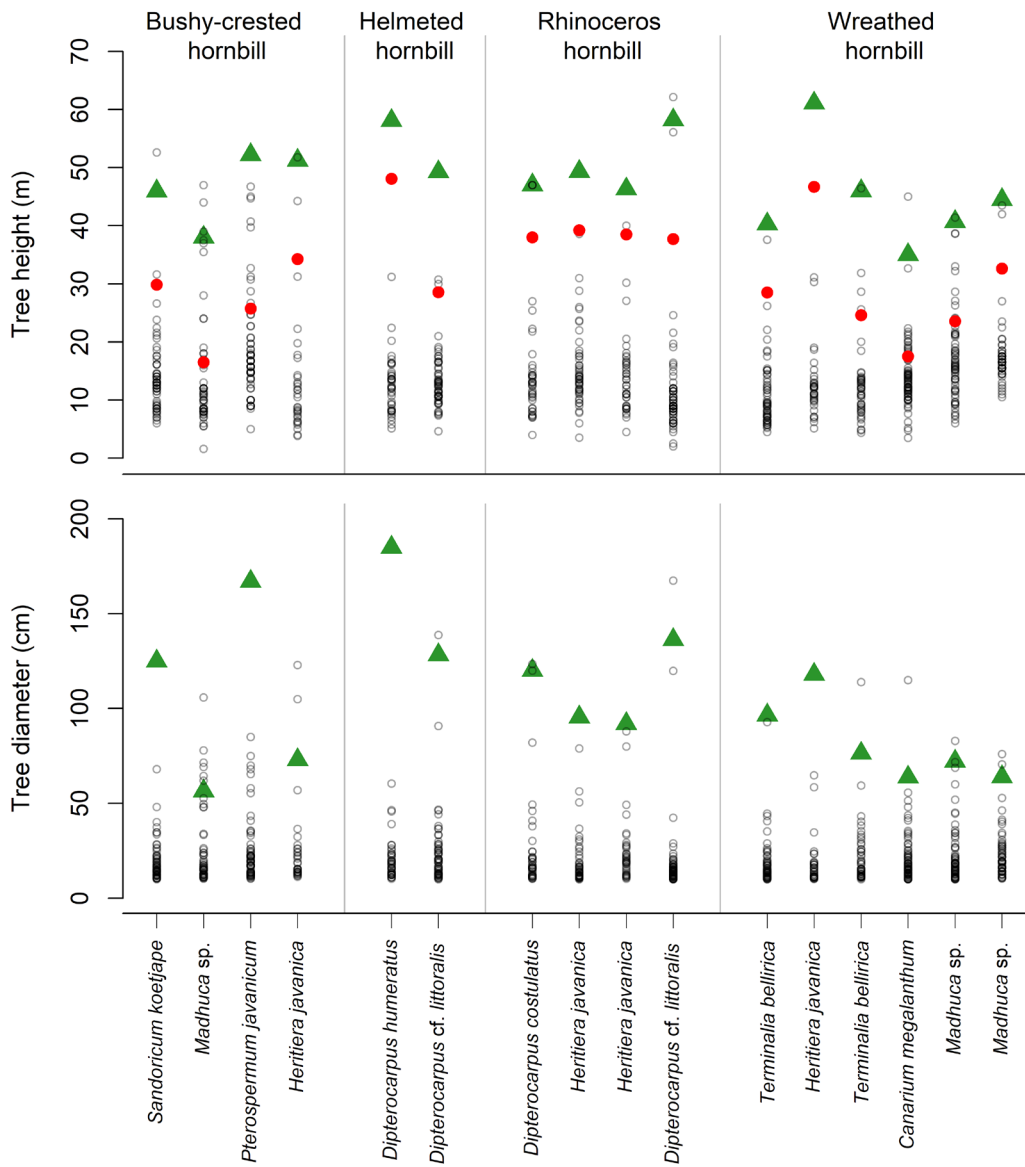


Fig. 3. Nest tree height (upper panel) and diameter (lower panel) compared to other trees surrounding the nest tree. Green triangles represent the height and diameter of the nesting trees. Red circles represent the height of nesting cavities from above the ground. Open black circles represent the other trees surrounding the nest trees within 20-m radius.

(Fig. 4). The ratio of nest entrance height vs. width was only significantly different between Wreathed Hornbill (mean = 2.55, SD = 0.67) and Bushy-crested Hornbill (mean = 0.84, SD = 0.21, Dunn test, $p = 0.0014$). All cavities used by Wreathed hornbill were more vertically elongated compared to other cavities used by the other hornbills, with the nest opening height reached 2.5 times longer than the width (Fig. 5).

Among the four hornbill species, only Bushy-crested hornbill preferred nests with particular entrance orientation, with a mean of 22° relative to compass direction (N = 4, Rayleigh $r = 0.86$, $p = 0.04$). The other three species did not have preference on nest entrance orientation (Helmeted hornbill N = 2, Rayleigh $r = 0.69$, $p = 0.45$; Rhinoceros hornbill N = 4, $r = 0.36$, $p = 0.63$; Wreathed hornbill N = 6, $r = 0.26$, $p = 0.69$; Fig. 6).

Tree species richness around the nesting trees of all hornbill species combined ranged between 15 and 48 species with an average of 31 species ($SD = 8.0$). There were no significant differences of tree diversity (Kruskal-Wallis test, $N = 16$, $df = 3$, $H = 1$, $p = 0.80$), species richness ($H = 0.37$, $p = 0.95$), and tree density ($H = 0.78$, $p = 0.85$) in the surrounding habitat of nesting cavities of the four hornbill species (Fig. 7).

Discussion

This research is a follow-up study of our earlier work (Utoyo et al. 2017) which only presented the nesting cycle and nest site characteristics of Helmeted and Wreathed hornbills in 2015 at WCRS. Here, we add records for Bushy-crested and Rhinoceros Hornbill (pre- and post-2015) and included detailed measurement of the nest site characteristics. In total, we recorded 29 breeding records of four hornbill species (Rhinoceros, Helmeted, Wreathed, and Bushy-crested hornbill), including three records described in Utoyo et al. (2017).

Based on our observation, Wreathed Hornbill tended to occupy vertically elongated cavities, different from Datta and Rawat (2004) who found that Wreathed Hornbill preferred oval cavities. Nest cavity of Helmeted Hornbill was the largest compared to other hornbill species; this might be due to its large body size relative to the other three hornbills. The smallest hornbill, the Bushy-crested Hornbill, used the smallest cavity size. Poonswad (1995) also reported that larger hornbill tended to select nest with longer nest entrance height.

As found in other studies (e.g. Hussain 1984, Poonswad et al. 1987, Poonswad 1995) hornbills tend to nest in holes of live trees, as in our study site. However, the information on the tree

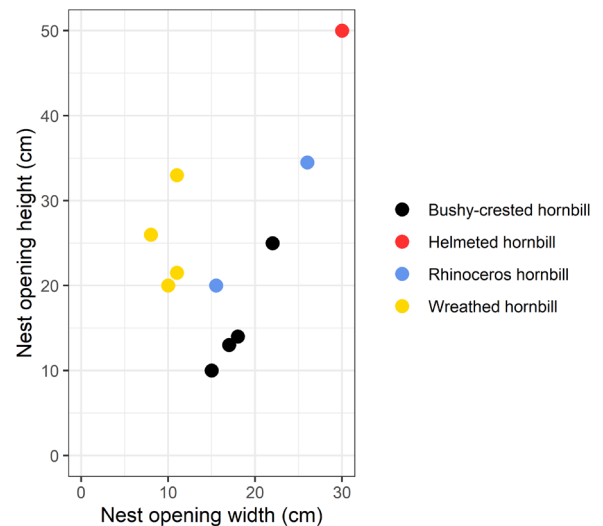


Fig. 4. Cavity opening dimensions (height x width) of the nests used by different species of hornbills.

species used for nesting in Southeast Asian tropical forests is relatively scarce (Poonswad 1995, Kinnaird and O'Brien 2007). Poonswad (1995) recorded five genera (*Dipterocarpus*, *Eugenia*, *Tetrameles*, *Nephelium*, and an unknown genus) utilized by the Wreathed hornbill. From our study, we added four more genera: *Madhuca*, *Canarium*, *Terminalia*, and *Heritiera*. Moreover, in our study site, as in Thailand (Poonswad 1995), hornbills selected the largest and emergent trees. This might be due to the possibility that the largest trees have larger and suitable cavities (Poonswad 1995), but might also reflect the trees available at particular sites (Kinnaird and O'Brien 2007).

We found that the nesting tree characteristics (cavity height, tree diameter, and tree height) and the ratio of nest opening (except between Bushy-crested and Wreathed hornbills) were not different among the four sympatric hornbill species in our study area. There was also no preference in cavity orientation (this study, Poonswad 1995, Datta and Rawat 2004), except for the Bushy-crested Hornbill. On the other hand, Poonswad (1995)



Fig. 5. Photographs of nest cavity entrances.

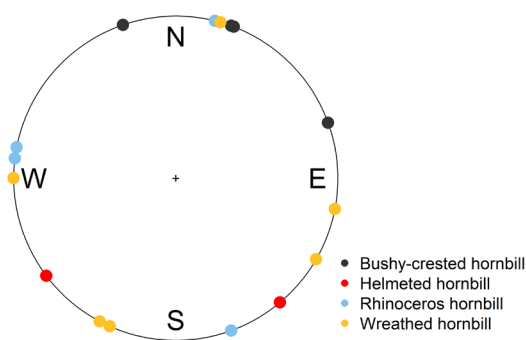


Fig. 6. Nest entrance orientation of four sympatric hornbills.

found differences of nest height, diameter at nest height, nest entrance height, and nest entrance width used by four sympatric hornbill species in Thailand. Similarly, Datta and Rawat (2004) found that the cavity size was the main variable that separated the three hornbill species in their study site in north-east India. Both studies might indicate that there was low competition pressure for nest-sites among the hornbills. In our study site, however, the similarity in nest-tree characteristics among the sympatric hornbills might have caused the three events of nest-site competition between 1) Helmeted and Wreathed hornbills, 2) Rhinoceros Hornbill and *Petaurista* sp., and 3) Wreathed and Rhinoceros hornbills. However, the lack of differences of nest characteristics might also be due to our small sample sizes.

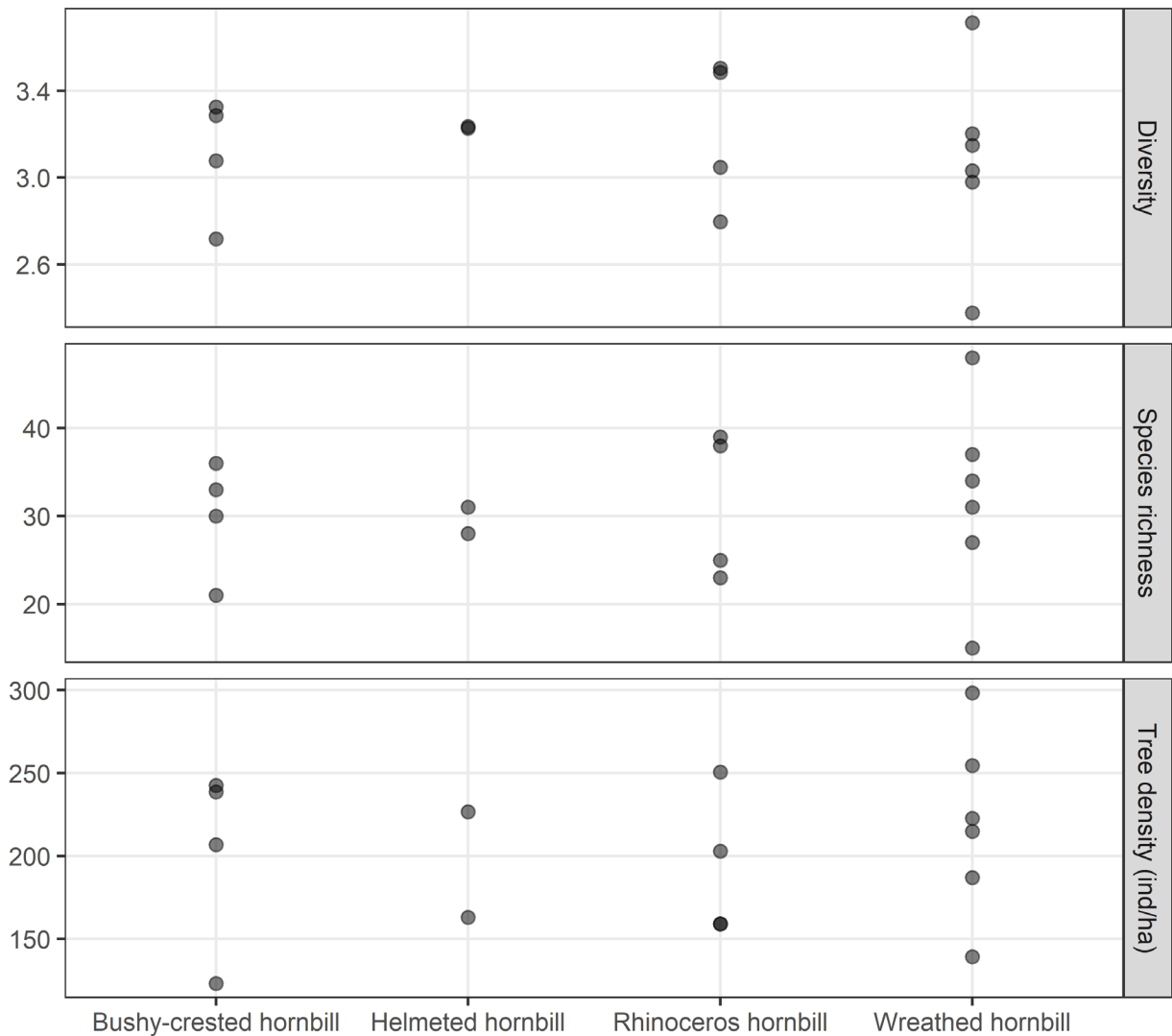


Fig. 7. Community structure of the trees within 20-m radius from the nesting trees. Diversity indices were calculated using Shannon Diversity Index. Species richness is the number of tree species per sampling unit. Tree density is the number of tree stems per hectare.

Kinnaird and O'Brien (2007) summarized the timing of breeding for hornbill species in the aseasonal equatorial region (Sumatra, Peninsular Malaysia, and Borneo) and found that they typically started nesting over the six months' period beginning in January (although Rhinoceros and Helmeted hornbills begin nesting during the wettest month, and the Bushy-crested and Wreathed hornbills initiate nesting throughout the year). Our results also generally concurred with this general pattern, but not for Rhinoceros and Wreathed hornbill. In addition, when rain

is less seasonal (as in Sumatra) the abundance of trees bearing flowers or fruit crops may provide cues that trigger nest initiation (Kinnaird and O'Brien 2007). We suspected that this was the possible reason for a significant decrease of nesting frequencies between the two monitoring periods (2006 – 2009 and 2015 – 2018). However, to establish this, further investigation of long-term phenology data is required (fortunately, phenology data are available since 1998 onward) and this can be examined in future research studies.

This study is limited because we could not conduct continuous daily observation nor frequent monitoring to avoid unnecessary disturbance to the breeding pair. As a result, we were unable to make an accurate estimation of the duration of the nesting stages. However, this caveat was traded off against the greater number of potential nesting cavities we could observe each month. Another limitation of this study was that we did not measure tree cavities that were not occupied by hornbills to determine their preference of nesting sites.

Conservation implications

Hornbills are threatened across Sumatra mainly due to habitat loss and illegal hunting for their casques. In order to increase their population, we need to ensure that sufficient nesting sites are available. Nesting trees are vulnerable to illegal logging due to their high timber value. For example, tree species of *Dipterocarpus* and *Sandoricum* have hard wood and are suitable for furniture and *Pterospermum* trees are easy to process. However, *Terminalia bellirica* is less preferred for timber because the wood is rather soft and easily attacked by termites (*pers. comm.* with local community). High intensity of illegal logging had occurred in BBSNP, but since 2004 the park has implemented better law enforcement and logging has greatly reduced. The population decline of emergent trees due to past illegal logging may hamper the reproduction cycle of hornbills and increase competition pressure for nesting sites between sympatric hornbill species.

Hornbills are easily targeted by poachers when they are foraging in fruiting trees or during nesting. Fig trees bearing fruits are often visited by hornbills, resulting in higher vulnerability for hunting. Although the information on Helmeted hornbill nesting period in published literature may increase the chance of misuse by hunters,

we believe this information can also inform conservation managers to increase patrolling effort during vulnerable time.

Considering the high risk of extinction to hornbills, we suggest the following conservation measures to safeguard hornbill populations:

- Increasing patrol effort during predicted period of hornbill nesting.
- Law enforcement on illegal logging of large trees in protected areas.
- Regular checks on known, previously-used tree cavities and restoring damaged cavities or maintaining available cavities.

Acknowledgments

We thank our field staff who collected the data in the field since 2006, especially Sukarman and Wiroto. We also thank Bukit Barisan Selatan National Park officials for the permission to conduct this long-term monitoring project, especially the park's forest ecosystem managers for WCRS, including Rikha A. Surya, Tri Sugiharti, Hagnyo Wandono, and Subki. Special thanks to donors (KfW-BBS and anonymous donor) who supported this activity.

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Appendix 1. Characteristics of hornbill nesting trees.

Hornbill species (length cm)	Nest tree species	Tree Family	DBH (cm)	Tree height (m)	First branch (m)	Nest height (m)	Cavity dimensions (height x width in cm)	Entrance orientation (°)
	<i>Pterospermum javanicum</i>	Malvaceae	167.0	52.2	34.7	25.7	13 x 17	341
Bushy-crested hornbill (65 – 70)	<i>Heritiera javanica</i>	Malvaceae	73.0	51.3	28.8	34.3	25 x 22	70
	<i>Sandoricum koetjape</i>	Meliaceae	125.0	46.0	17.6	29.9	14 x 18	21
	<i>Madhuca</i> sp.	Sapotaceae	56.5	38.0	29.0	16.5	10 x 15	20
Rhinoceros hornbill (80 – 90)	<i>Dipterocarpus</i> cf.	Dipterocarpaceae	136.2	58.2	36.3	37.7	34.5 x 26	160
	<i>Heritiera javanica</i>	Malvaceae	95.5	49.3	43.5	39.2	*	277
	<i>Dipterocarpus costulatus</i>	Dipterocarpaceae	120.0	47.0	32.0	38.0	20 x 15.5	14
	<i>Heritiera javanica</i>	Malvaceae	92.0	46.3	25.5	38.5	*	281
Helmeted hornbill (110 – 120)	<i>Dipterocarpus humeratus</i>	Dipterocarpaceae	185.0	58.1	41.1	48.1	50 x 30	140
Wreathed hornbill (75 – 85)	<i>Madhuca</i> sp.	Sapotaceae	72.3	40.7	27.3	23.5	*	120
	<i>Canarium megalanthum</i>	Burseraceae	63.8	35.0	24.0	17.5	*	208
	<i>Madhuca</i> sp.	Sapotaceae	64.0	44.5	18.5	32.6	21.5 x 11	16
	<i>Terminalia bellirica</i>	Combretaceae	96.5	40.3	22.6	28.5	20 x 10	270
	<i>Terminalia bellirica</i>	Combretaceae	76.4	46.0	23.6	24.6	26 x 8	101
	<i>Heritiera javanica</i>	Malvaceae	118.0	61.1	34.8	46.7	33 x 11	204

* No nest entrance measurement because when the measurement survey was conducted, the cavities were still being occupied by hornbills.

Notes from the field

Sighting records of hornbills in western Brunei Darussalam

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The island of Borneo supports eight species of hornbills in the genera *Anorrhinus* (Bushy-crested hornbill *A. galeritus*), *Anthracosceros* (Oriental Pied hornbill *A. albirostris* and Black hornbill *A. malayanus*), *Berenicornis* (White-crowned hornbill *B. comatus*), *Buceros* (Rhinoceros hornbill *B. rhinoceros*), *Rhabdotorrhinus* (Wrinkled hornbill *R. corrugatus*), *Rhinoplax* (Helmeted hornbill *R. vigil*) and *Rhyticeros* (Wreathed hornbill *R. undulates*); all eight occur in Brunei Darussalam (hereinafter Brunei) at the north-western coast of Borneo (Phillips and Phillips 2011; Eaton et al. 2016).

Seven of the eight Bornean hornbill species are considered threatened by the IUCN Red List of Threatened Species: Helmeted hornbill is listed as Critically Endangered; White-crowned and Wrinkled hornbills as Endangered; Black, Rhinoceros and Wreathed hornbills as Vulnerable; and Bushy-crested hornbill as Near Threatened (BirdLife International 2016, 2018a-g).

Brunei is a small, low-lying nation measuring 5,765 km² in size with about 60% of the country covered in old-growth forest. The author with friends visited the Belait District (hereinafter

Belait) of western Brunei for leisure birdwatching during 10 – 13 July 2018. Belait is bordered by Miri of the Malaysian state of Sarawak, and urban development is limited to a thin coastal strip; much of the remaining land is covered in vast tracts of unbroken, old-growth forests. Peat swamp forests dominate the lowlands around Kuala Balai and Badas areas, while hill dipterocarp forests cover the low hills around the Labi area up to Bukit Teraja.

We visited three major areas during our visit (Fig. 1); all site names mentioned can be found in Google Maps.

During our trip we had multiple records of five hornbill species, including Black hornbill (Fig. 2), Bushy-crested hornbill (Fig. 3), Oriental Pied hornbill (Fig. 4), Wreathed hornbill and Wrinkled hornbill (Fig. 5). See Appendix for details of our observations. Of these observations, the repeated sightings of the Endangered Wrinkled hornbill, especially the large flock at Jalan Mumong (known as KB Road amongst birders) of Kuala Balai area is of particular interest. Eaton et al (2016) reported the species' social behaviour as "*Pairs, occasionally small groups*

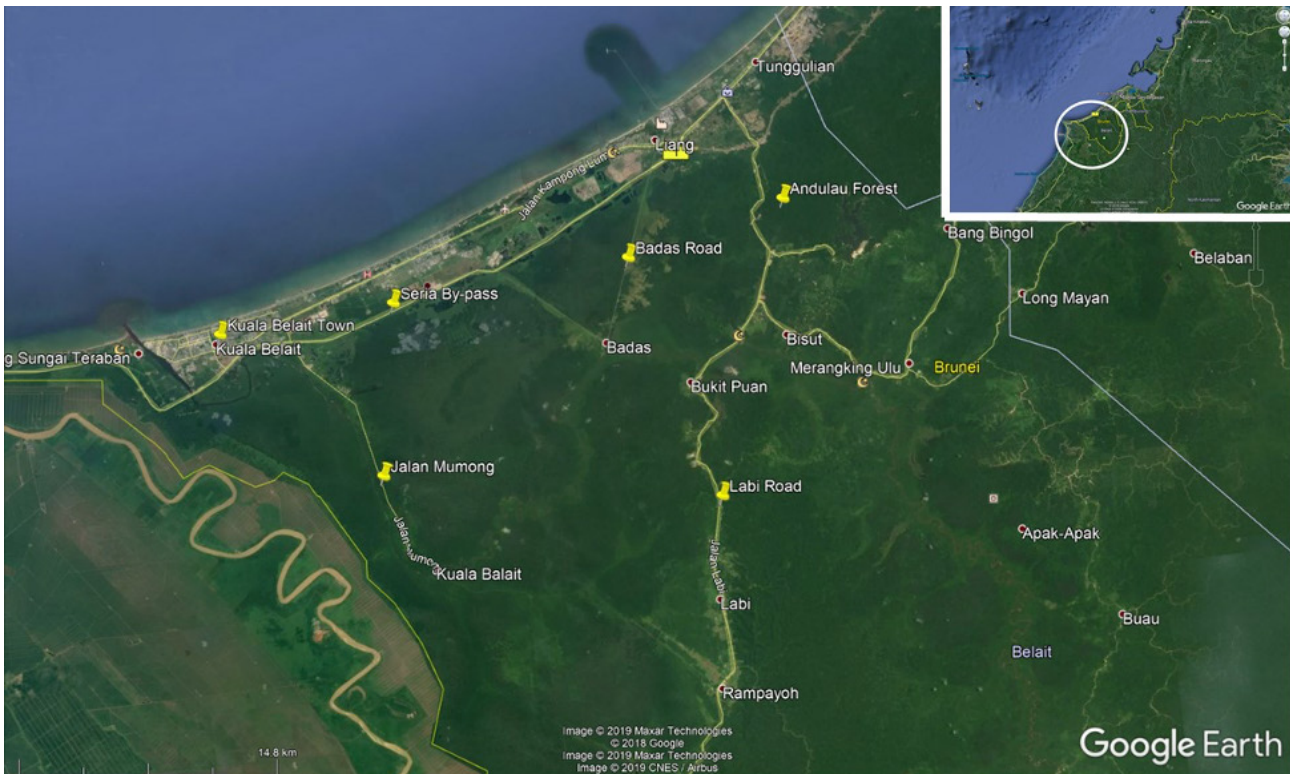


Fig. 1. Sites mentioned for hornbills observed in the Belait District, in Brunei Darussalam during 10 – 13 July 2018, Insert shows location of Belait District Brunei Darussalam.

(<10)", and the species is considered "always uncommon" restricted to Sundaic primary lowland forests (BirdLife International 2018e). Although we did not observe the globally threatened White-crowned hornbill, Rhinoceros hornbill or Helmeted hornbill during our visit, each site was visited briefly and only the periphery of these forest blocks were explored. In view of the expanse and excellent quality of Brunei's natural forests, this tiny nation may be a stronghold for these increasingly threatened hornbill species in addition to the obviously healthy population of Wrinkled hornbill.

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Appendix 1. Details of hornbill observations in the Belait District, Brunei during 10 – 13 July 2018. For site location see figure 1.

Species	Site (Date)	No.	Notes
Black hornbill <i>Anthracoseros malayanus</i>	Badas Road (11 Jul)	2	Single male in flight on two occasions in peat swamp forest
Bushy-crested hornbill <i>Anorrhinus galeritus</i>	Labi Road (13 Jul)	1	Male in flight near Tapang Lupak in hill dipterocarp forest
	Jalan Mumong (10,11, 13 Jul)	> 20	Seen numerous times by forest edge, in small groups
Oriental Pied hornbill <i>Anthracoseros albirostris</i>	Kuala Belait Town (10,11 Jul)	2	Pair perched on lamp post in busy built-up area
	Seria By-pass between Kuala Belait Town and Badas Road (11 Jul)	2	Flew cross a 4-lane highway
Wreathed hornbill <i>Rhyticeros undulates</i>	Labi Road (12 Jul)	2	Single males in flight near Mendaram Kechil and Lalak Lake National Park in hill dipterocarp forest
	Jalan Mumong (10 Jul)	24	Large flock flying high in the evening
	Jalan Mumong (11 Jul)	> 20	Observed in the morning, probably of the same group observed on 10 Jul
Wrinkled hornbill <i>Rhabdotorrhinus corrugatus</i>	Badas Road (11 Jul)	1	Flew across peat swamp forest
	Labi Road (12,13 Jul)	3	Singles in flight near Andulau Forest, Lalak Lake and Tapang Lupak in hill dipterocarp forest



Fig. 2. Male Black hornbill *Anthracoceros malayanus* at Badas Road, Belait District, Brunei Darussalam, 11 July 2018. Photo by Mak Chi-fung.



Fig. 3. Male Bushy-crested hornbill *Anorrhinus galeritus* at Labi Road, Belait District, Brunei Darussalam, 13 July 2018. Photo by Mak Chi-fung.



Fig. 4. Female Oriental Pied hornbill *Anthracoceros albirostris* at Kuala Belait Town, Belait District, Brunei Darussalam, 11 July 2018. Photo by Mak Chi-fung.



Fig. 5. A pair of Wrinkled hornbills *Rhabdotorrhinus corrugatus* at Jalan Mumong, Belait District, Brunei Darussalam, 10 July 2018. Photo by Mak Chi-fung.

Trumpeter hornbill (*Bycanistes bucinator*) bill colouration

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An observant birder, Hazel Nevin, from the KwaZulu-Natal (KZN) South Coast, South Africa recently inquired whether the male Trumpeter hornbill *Bycanistes bucinator* she had photographed had an injury to the back of its casque, resembling a raw wound. This summation may appear accurate but in this instance was incorrect. Adult Trumpeter hornbills all display a reddish or deep pink colour to the “blunt” or rear end of their casques (Fig. 1) This growth tissue is more prominent in males, but because the rear end to the casque is usually concealed by feathers, it is not often observed. The interesting fact about the reddish rear end to the

casque is that it is not a seasonal phenomenon, as the reddish colour does not change in brightness, or intensity between breeding, and non-breeding seasons. Photographic evidence shows that the rear casque end is as red in the winter, non-breeding months as it is during the breeding and summer season, and almost matches the colour of their facial skin (Fig. 2). Trumpeter hornbills are unique in this respect. No other hornbills in Africa show this rear end casque colouration, although Silvery-cheeked hornbills *Bycanistes brevis* seem to show very slight rear casque colouration when breeding, but not in the non-breeding season. Observ-



Fig. 1. A mature male with a well-worn casque that reaches the tip of its bill (August). Note the serrated bill that enables it to get a better grip on hard, slippery fruit and prey such as woodlice and millipedes.



Fig. 2. A male preening a female in mid-winter shows the pinkish rear end to its casque.



Fig. 3. The red rear end to the casque is usually covered, as with this bird collecting mud to plaster its nest entrance (end October).

ing male Trumpeter hornbills from side-on, the reddish rear end to the casque is often difficult to detect as it is usually covered by feathers (Fig. 3). The reddish casque patch is more difficult to detect in females as the casque doesn't protrude as high as in males (Fig. 4). Unlike many other hornbill species that have relatively smooth, shiny looking bills, those of

the Trumpeter hornbill are rough-looking, often well-worn and even flaky (Fig. 5). Bills which appear "clean" and polished are only observed in juveniles recently emerged from their nests. Their bills are more pale than adults and have a shiny, glossy appearance, however, the reddish casque patch is still observed (Fig. 6 and 7). The juveniles also display rufous-coloured



Fig. 4. The juvenile male on the left has a more robust (and growing) casque than the mature female on the right that has a blunt front end to the casque.



Fig. 5. A mature female showing an aged, well-worn bill, and typically, a short ‘half-length’ casque (October). The reddish casque patch is partially visible



Fig. 6. Even young birds such as this immature male shows the red/pink casque patch.

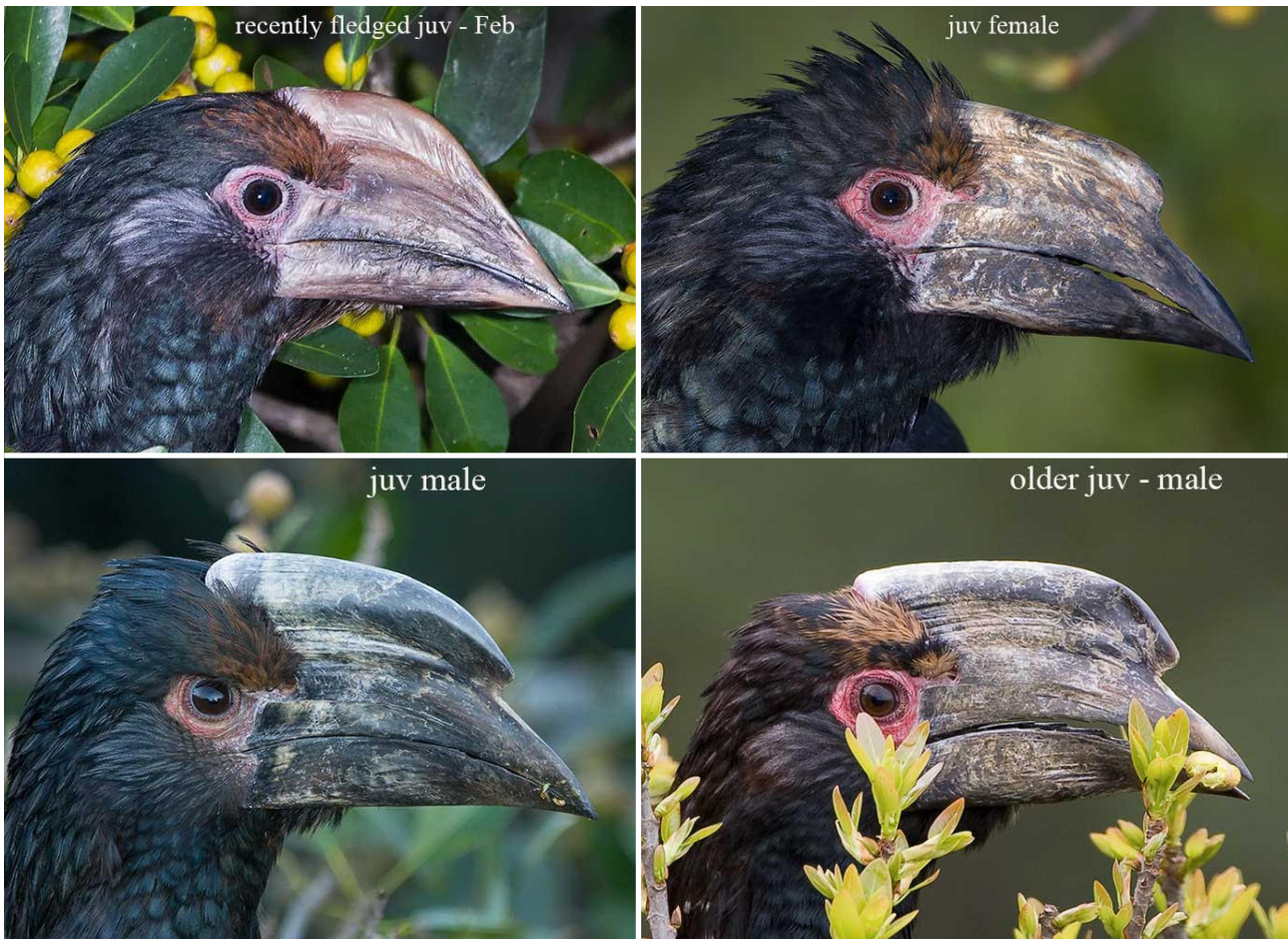


Fig. 7. The rufous colouration on juveniles varies with age. At a distance, juvenile males are difficult to separate from adult females.

forecrown feathers for the first few years after fledging. These rufous-coloured feathers vary in intensity and with age (Fig. 7).

Finally, Next time you find yourself standing near Trumpeter hornbills, salute these remarkable creatures. My world would definitely be a lot poorer without them.

Acknowledgments

I thank Alan Kemp for useful comments and Jarryd Alexander for editing this note for publication in the Hornbill Natural History and Conservation.

Nest Cavity Availability Determines Breeding in Hornbills: Rufous-necked Hornbill Nest at Breast Height in Bhutan

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Hornbills are a large-bodied, wide-ranging and ecological significant group of birds in the tropical and subtropical forests of Africa and Asia (Kinnaird and O'Brien 2007; Keartumsom et al. 2011). Known as farmers of forest, hornbills play important functional role as seed dispersers in the tropical ecosystem (Kitamura 2011). Among 62 living species of hornbills occurring globally, 32 species are reported to inhabit Asian forests, with four species occurring in Bhutan (IUCN-Hornbill SSC Group, 2019). The Rufous-necked hornbill (RNH, Family Bucerotidae, Order Bucerotiformes) is distributed in the evergreen forests of Bhutan, Myanmar, China, Thailand, Laos, Vietnam, and Northeast India (IUCN, 2019). With an estimated global population of 7000 to 10,000 mature individuals, it has been classified in vulnerable category (IUCN, 2019) owing to the rapid decline in population as a result of the destruction of evergreen forest and hunting (Bird Life International 2001). Here, we report an observation of an unusually low nest of Rufous-necked hornbill in south-central Bhutan.

During an ecological study from July 2014 to May 2016, a nest of the Rufous-necked hornbill was observed as low as at the breast height at Patsaling geog, Tsirang Bhutan (26°55'29.87"N, 90°6'17.57"E) at an elevation of 980 masl (Fig. 1). The

nest was located at only 1.3 m above ground on a *Crateva religiosa* tree. The nest tree has the diameter of 180 mm with the height of 19 m. Following south east aspect, the nest tree was located on a steep slope with the gradient of 45° in a warm broad-leaved forest under Tsirang Forest Division jurisdiction. Since 2016, the nest has been monitored during the breeding season (between March to August) till date. The breeding pair successfully nested for last three years, fledging with one to two chicks annually (Table 1).

According to Kemp (1995), the nest height range of Rufous-necked Hornbill ranges from 10 – 20 m above the ground. Similarly, Dorji (2013) during his study on RNH in Jigme Singye Wangchuck National

Table 1. No. of chicks fledged

Year	No. of chicks fledged	Sex of juveniles
2016	2	1 male and 1 female
2017	1	1 male
2018	Inactive	-
2019	2	1 male and 1 female



Fig. 1. The sealed nest cavity of Rufous-necked hornbill at 1.3 meters above ground.



Fig. 2. Male Rufous-necked hornbill feeding his family.

Park, Bhutan, reported the nest height at 10 – 20 m, consistent with Kemp (1995). Further, Rufous-necked Hornbill nests at cavity height range from 6.1 m to 33 m were recorded during their breeding biology study at Huai Kha Khaeng Wildlife Sanctuary in

western Thailand (Chimchome et al. 1995). Sherub and Tshering (2019) recorded an inactive nest during their population assessment and nesting behavioural study at Gomphu in Zhemgang, Bhutan, at 2 m above the ground with the nest height range



Fig. 3. Male juvenile Rufous-necked hornbill of 2017.

from 2 to 23 m above ground. Our present record confirms the lowest nest cavity height (1.3 m) recorded for Rufous-necked Hornbill. The bird might have opted to nest at the lower height as they found a suitable nest cavity without disturbance. Moreover, the nest tree is located on a steep area where it is hard for human and other predators to access. Also, the strong conservation policies, rules and regulations, and patrolling carried out by the frontline staff of Tsirang Forest Division, Bhutan, has ensured there is no record of hornbill poaching in the area. We recommend continuous annual monitoring of the nest site and initiating suitable nest management activities, if deemed necessary, in the coming years. Further, a detailed study on nest tree availability, nest tree selection, nest site selection and nesting architecture of Rufous-necked Hornbill in the study area is deemed necessary.

Acknowledgments

Thanks are due to the Honourable Director, Department of Forest and Park services, Bhutan, for granting research permission. We thank Dr. Sherub, Principal Research Officer of Ugyen Wangchuck Institute for Conservation and Environmental Research, Bumthang, for his encouragement and support. In particular, the authors would like to acknowledge IDEAWILD for supporting field equipment, Rufford Small Grants for Nature Conservation and Oriental Bird Club, UK for funding the ecological study in 2016.

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Flocking of hornbills observed in Tongbiguan Nature Reserve, Yunnan, China

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Flocking behaviour are often observed in Asian hornbills (Kinnaird and O'Brien 2007). In Thailand, over 1 000 Wreathed hornbill *Rhyticeros undulatus* have been seen flocking together to roost site (Poonswad and Kemp 1993), while in Malaysia, a gathering of 2 421 Plain-pouched hornbills *Rhyticeros subruficollis* was reported (Ho and Supari 2000).

However, for the five species of hornbills found in China (Rufous-necked hornbill *Aceros nipalensis*, Austen's Brown hornbill *Anorrhinus austeni*, Oriental Pied hornbill *Anthracoceros albirostris*, Great hornbill *Buceros bicornis* and Wreathed hornbill), the documentation of flocking behaviour is absent. During a recent field survey on 12th October 2019, staff from Tongbiguan Nature Reserve (TBG), situated in Dehong Prefecture at the western part of Yunnan Province adjoining Myanmar's Kachin State, were thrilled to observe a large flock of 102 Wreathed hornbills and 45 Great hornbills (Fig. 1), which was the largest hornbill flock ever recorded in China.

TBG was established in 1986 to preserve the unique biodiversity of the region. It is within the distribution range of all five species of hornbills found in China, and is widely known as "Horn-

bill Valley" among Chinese birders. In China, Wreathed hornbill only occurs in TBG while the Great hornbill is being regularly seen here only in recent years. As the only tropical region of the Irrawaddy River Basin in China, TBG is part of WWF's Northern Indochina subtropical forests ecoregion (IM0137), CI's Indo-Burma biodiversity hotspot and BirdLife's Important Bird Area (CN245). TBG is also home to the largest patch of *Shorea*-dominated dipterocarp rainforest in China (Fig. 2), with a large population of the large deciduous tree *Tetrameles nudiflora* which could be potential nest trees for hornbills as has been reported in other studies (Poonswad 1995, Datta and Rawat 2004).

Dedicated hornbill conservation work in TBG started in 2015 after Kadoorie Farm and Botanic Garden (KFBG), TBG and the local government co-organised an international workshop on hornbill conservation in China in Yingjiang County of Dehong Prefecture. Delegates of the Yingjiang workshop, including hornbill experts like Pilai Poonswad and Aparajita Datta, called for enhanced conservation effort for Chinese hornbills. The relevant government agencies have taken the advice seriously. TBG started to monitor and record nesting activities and breeding success of Wreathed hornbill, Great hornbill and Oriental Pied hornbill for five consecutive years since 2015. In 2019, 12 nests,



Fig. 1. Sixteen of the 45 Great hornbills observed on 12th October 2019; the largest flock recorded in China (photo credit: Ding-Ying Ban)



Fig. 2. Tongbiguan Nature Reserve has the largest patch of *Shorea*-dominated dipterocarp rainforest in China with high plant endemism.



Fig. 3. A nest of Wreathed hornbill being monitored in Tongbiguan Nature Reserve.

including six of Wreathed hornbill, four of Great hornbill and two of Oriental Pied hornbill were intensely monitored by TBG during the breeding season (pers. obs. by the authors; Fig. 3).

In recent years, TBG has been collaborating with KFBG and other conservation organizations to explore sustainable conservation initiatives. By developing sustainable ecotourism in community forests with hornbills in villages surrounding TBG, many of the local communities have been inspired and are engaged in the conservation of the last stronghold of hornbills in China. KFBG and TBG are developing Indigenous and Community Conserved Areas (IC-CAs) in community forest blocks with hornbill nesting trees, and we hope such effort could further enhance the long-term survival of hornbills in this corner of China.

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Hornbill news

Update from the Helmeted Hornbill Working Group

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We provide here updates from the Helmeted Hornbill Working Group (HHWG).

1. CITES COP 18 in Geneva, Switzerland (August 2019):

Several members of the HHWG may have followed the meeting hosted by Sarawak Forestry Corporation in February 2019 in Miri (Sarawak, Malaysia) in which experts (including several HHWG members) met and revised the Resolution Conference 17.11 to expand its focus of Helmeted hornbill conservation from range countries to include transit and demand countries.

The revised document 84 was tabled at COP 18 in Geneva on 20 August 2019 by Indonesia (Fig. 1). Malaysia made an intervention, requesting all parties to adopt it. Several others supported the document including governments of China, USA, and the EU, besides NGOs. However, a revision was requested to be made. A working group to review the proposed amendments was made (comprising of Parties, NGOs, CITES Secretariat). We understand that they have already revised the proposed document.

We would like to extend our kudos to Yok Hadiprakersa (Rangkong Indonesia), Kanitha Krishnasamy

(TRAFFIC), Madhu Rao and Sue Liebermann (WCS), and others who were physically present at the COP and rallied its support for the species. The new document will ensure that the CITES Secretariat shall request Parties—especially the range, transit and consumer states—for the implementation of Resolution Conference 17.11 for the conservation of the Helmeted hornbill.

2. Recent poaching incidents

There has been recent news about the first confirmed Helmeted hornbill poaching incident in Thailand (Bangkok Post 2019; Thai PBS News 2019). The news generated quite a turmoil in Thai social media, even a petition was created and circulated (Coconuts Bangkok 2019). There has also been news about Helmeted hornbill products being sold in Thailand but fortunately, monks and celebrities have spoken against their superstitious use.

We have since learned from Dr Vijak Chimchome that the poacher was not specialised in Helmeted hornbill hunting and is being kept an eye on. In a positive development, Department of National Parks (Thai govt) has given a go-ahead for the development of national Helmeted hornbill action plan.

Some seizures in Sarawak have also been recently made.

3. Contributing to HHWG subgroups and tracking the progress of action plan

Most subgroup leads have followed up with members on progress updates in 2019 so far. There are far too many to list here, but we are heartened to see several rapid assessments and detailed surveys being undertaken at the range countries. Actions on the transit and demand side seem to be slower but are also happening.

The HHWG subgroup leads meet remotely and members and others may please share your updates with them from time to time so they can be captured in one place. We are using these action updates to track the progress of the Helmeted hornbill action plan.

4. Change in trade subgroup leadership and state facilitators

Dr. Chris Shepherd of Monitor has stepped down as lead of the trade subgroup though he is still a member and contributor to HHWG. Ms. Serene Chng of TRAFFIC is now leading the trade subgroup, co-lead by Mr. Dwi Adhiasto of WCS. Dr. Jiraporn Teampanpong has stepped down as Thailand state facilitator and has been replaced by Mr. Somkiat Soontompitakkool from DNP. The list of all state facilitators in HHWG so far are:

- Mr. Lay Win for Myanmar
- Mr. Somkiat Soontompitakkool (DNP) for Thailand
- Md. Khusaini (Perhilitan) for Peninsular Malaysia
- Mr. Oswald Braken (SFC) for Sarawak
- Mr. Yok Hadiprakarsa (Rangkong Indonesia) for Indonesia

5. Stand against sensational reporting

The media article in August on helmeted hornbills on the front cover of the *Star News* in Malaysia was an example of irresponsibly sensational reporting. While the reporters may have good intentions (raise awareness about an emerging wildlife issue), the sensational title ('WANTED! There's a price on this bird's head') and related emphasis may actually do more harm than good and lead to driving demand (Fig. 2). The HHWG coordinators and leads felt concerned and put together a response letter which Dr Aparajita Datta, as IUCN SSC Hornbill Specialist Group Chair, sent to the Chief Editor of *Star News* highlighting our concerns. We didn't hear back.

A general point to take note is that we, as HHWG members, should be very careful not to indulge in any form of sensational reporting on Helmeted hornbill. Also, DON'T use the term 'red ivory' for Helmeted Hornbill or quote the price of the casque as much as possible.

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Fig. 1. Yok Yok Hadiprakarsa of Rangkong Indonesia delivering an intervention on the conservation of the Helmeted Hornbill at the CITES COP in Geneva, Switzerland.



Fig. 2. A sensational article that appeared on the front cover of the Star News in Malaysia in August 2019. HSG members should be careful to not indulge in sensational reporting that can cause more harm to the species by stimulating demand for illegal trade

IUCN HSG Update and Activities

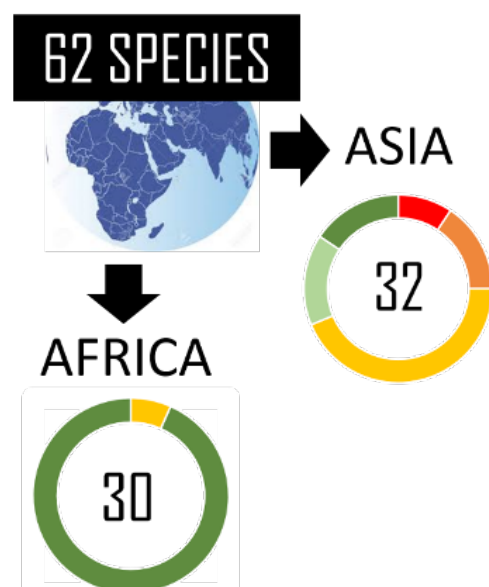
The IUCN Hornbill Specialist Group, which existed in the eighties, was revived because the plight of hornbills continues to deteriorate, with various additional species becoming threatened and a growing number, nationally and globally becoming Endangered, several of them Critically.

The proposal to re-establish the IUCN Hornbill Specialist Group was accepted in late 2017 and the Group was formed in November 2017. The objectives of the IUCN Hornbill Specialist Group (HSG) is to provide leadership for the conservation of all 62 hornbill species (32 in Asia, 30 in Africa), determine and review on a continuing basis the status and needs of hornbills, and promote the implementation of necessary research, conservation and management programmes by appropriate organizations and governments, make known the status and conservation needs of hornbills, and promote the wise management of hornbill species. The Hornbill Specialist Group can also facilitate better networking and training to encourage further research to understand the status, distribution and biology of hornbills across range countries.

Currently, three species are listed as Critically Endangered, five as Endangered, 16 as Vulnerable, five as Near Threatened and 33 as Least Concern. Most of the 24 hornbill species under the three threatened categories occur in the Asian region and by calling on the expertise and experience of local and regional experts, the group will be able to access the political, social and economic support that will enable activation of priority and positive interventions in support of threatened species. Many of the African species currently listed as Least Concern need more updated data and studies to ascertain their current status. The Hornbill Special-

ist Group can also facilitate better networking and training to encourage further research to understand the status, distribution and biology of hornbills across range countries.

We identified seven SSC HSG targets/activities for the 2017-2020 quadrennium.



These were:

1. Website and social media established and maintained (2018-19);
2. Initiate an action plan workshop for the Critically Endangered Sulu Hornbill (2019);
3. Prioritise species requiring formal conservation plans (2019). We will ensure we have achieved this for the CR and EN species within this quadrennium;
4. Annual regional capacity building workshops (2020);
5. Support the International Hornbill Conference in 2021 in Bhutan (2021);
6. Increase African membership (2020);

Our vision and mission



A world where all hornbill species thrive in viable, wild populations in secure habitat because people cherish them.



The HSG aims to **use our combined knowledge and skills for evidence-based conservation action of hornbills and their habitats.**

Activities undertaken/milestones

7. One or two newsletters per year (2020).

This will allow for sharing of projects and data that may not reach formal peer-reviewed journals.

Membership

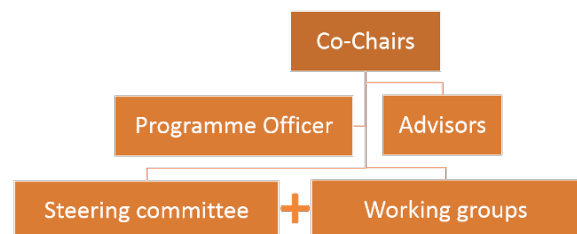
Since the Hornbill SG was formed, we have established a membership of 142 members from 29 countries (18 from Africa, 106 from Asia and 18 from Europe/USA).

Secretariat and governance

We appointed an Advisory group (4 members) and a Steering Committee (9 members) for the IUCN HSG based on the needs of the group. Apart from the two co-Chairs of the IUCN SSC Hornbill Specialist Group, there are seven Steering Committee members. These include Dr. Koen Brouwer, Dr. Divya Mudappa, Mr. Yok-yok Hadiprakarsa, Dr. Vijak Chimchome, Mr. Yeap Chin Aik, Mr. Paul Schutz and Dr. JC Gonzalez. The Advisory Board members are Dr. Alan Kemp, Dr. Pilai Poonswad, Dr. Margaret Kinnaird and Dr. Tim O'Brien based on their long-standing experience/expertise and interest in hornbills. Ms. Bee Choo Strange has helped facilitate the work of the HSG and worked in a volun-

tary capacity as the Program officer for the group.

- 1st Steering Committee meeting of the IUCN SSC Hornbill Specialist Group: (Bangkok, 26th to 28th August 2018).
- Supported by Wildlife Reserves Singapore & Disney 2nd Steering Committee meeting of the IUCN SSC Hornbill Specialist Group (Bangalore, 16th – 18th May 2019). Supported fully by Wildlife Reserves Singapore.



Communications

Website:

Our website was established in 2018: <http://www.iucnhornbills.org/> and is a work-in-progress. Please submit ideas or materials to enable us to build a central go-to place for all things hornbill.

Social media:

Facebook page – ‘IUCN Hornbill Specialist Group’ was established in 2018, which was initially open only to HSG members, but has subsequently been made a public group. Currently it has 697 members which continues to grow daily. Eric Kowalczyk, formerly of the Woodland Park Zoo and Friend of the HSG acts as Admin for the group along with the Co-Chairs. This is a Facebook group for Hornbills created and moderated by the IUCN Hornbill Specialist Group. It will be used for sharing updates, announcements, news, information related to both in-situ and ex-situ hornbill research and conservation in Asia and Africa. It is aimed at increasing public awareness, knowledge, interest and love for hornbills.

Newsletter - A newsletter called ‘**Hornbill Natural History and Conservation**’ established. Articles were solicited from HSG members in August 2019. The Editorial Committee consists of Dr. Tim O’Brien, Dr. Divya Mudappa, Dr. Shankar Raman, and Dr. Jarryd Alexander reviewed the submitted articles.

Listserve: We also established a ‘Hornbill SG Network’ Googlegroups listserv in February 2019 for internal member communications/discussions and sharing of information. 119 members have joined this listserv. Any member can post, share and initiate discussions.

We are in the process of developing a com-

munications plan/strategy for the HSG both for internal member engagement and communications, and for external communications and conservation messaging. Other social media accounts on Twitter and Instagram would be opened after a strategy is in place.

Working groups

- There are two active Working groups – the Helmeted Hornbill Working Group and the Southern Ground Hornbill Working Group – both of which pre-date the formation of the HSG. The Helmeted Hornbill Working Group works closely with the HSG and is coordinated by Anuj Jain (Birdlife) and Jessica Lee (WRS). We have planned five other Working Groups (Philippines Hornbill WG, In-situ Conservation Management WG, Ex-situ Conservation Management WG, Research & Training WG, Red-Listing WG) that are yet to be established. However, review and work for updating IUCN Redlist assessments for species has been underway by reaching out to HSG members without the formal establishment of the proposed Red-Listing Working Group.

Conservation action plans

- Launched IUCN SSC CPSG-led 10-year **Helmeted Hornbill Action Plan** (Bangkok, 29th August 2018)
- The IUCN SSC Hornbill Specialist Group took the lead in initiating the planning for the **Sulu Hornbill Conservation Action Workshop** (Manila, 4th – 6th March 2019). The workshop was carried out in partnership with IUCN SSC Conservation Planning Specialist Group (CPSG), and partner organizations (Philippines Biodiversity Conservation Foundation, Inc., Birding Adventure Philippines, Hornbill Research Foundation). The workshop was supported by Wildlife Reserves Singapore, USAID and CPSG.

Red-list assessments

- Updated Red List assessments underway with two interns, supported by Chester Zoo, Dr Kathryn Gamble and Milwaukee Zoo, in both Africa and Asia working to reassess a number of lesser-known species to ensure all species have the most accurate conservation status possible, to enable swift and prioritized conservation action for the most threatened. The species factsheets are also being reviewed and updated by reaching out to our network of members.

Upcoming

- A proposal for listing the African *Ceratogymna* spp. hornbills as Appendix II is underway.
- There will be both a dedicated Symposium on African hornbills, and a conservation status round-table discussion, at the Pan-African Ornithological Conference in November 2020, Victoria Falls, Zimbabwe.
- We are currently fund-raising for preliminary research on the Northern Ground Hornbill in three study-sites: Chad, Benin and Ethiopia to enable a conservation planning workshop to take place.

Financial

- To date, the HSG has raised \$ 32,000. This includes the support for the meetings and workshops mentioned above. This includes an internal IUCN grant of \$3500 announced in August 2019 for supporting communications/outreach and some support for program officer.
- Wildlife Reserves Singapore has provided a major part of the support for the HSG activities till date and from April 2020 onwards has committed to providing annual support for the HSG activities for 3 years. We are very happy to state that Wildlife Reserves Singapore will be the host institution for the HSG.

this listserv. Any member can post, share and initiate discussions.

We are in the process of developing a communications plan/strategy for the HSG both for internal member engagement and communications, and for external communications and conservation messaging. Other social media accounts on Twitter and Instagram would be opened after a strategy is in place.

Acknowledgments

All of us are working in a voluntary capacity for the HSG and so we thank all of you, the members, our Advisory board, the Steering Committee, the Editorial Board of the newsletter and those in the IUCN SSC Chair and their office for their support as we find our feet and gather momentum. The key partner organizations who have supported the activities/work undertaken thus far are the Mabula Ground Hornbill Project, Nature Conservation Foundation, Wildlife Reserves Singapore, Hornbill Research Foundation, Rangkong Indonesia, Attica Zoological Park, Malaysian Nature Society, Disney Animal Kingdom, Kaset-

sart University, EAZA Hornbill Tag, Maguari One-Zoo & Wildlife Consultants, and the Wildlife Conservation Society. Individuals from several other institutions such as TRAFFIC, Chester Zoo, North Carolina Zoo, Philippines Biodiversity Conservation Foundation Inc. (PBCFI), Birdlife International, Talarak Foundation, Milwaukee Zoo, Dr Kathryn Gamble, and especially the IUCN SSC Conservation Planning Specialist Group have also helped tremendously during the conservation action planning workshops and/or participated/worked in collaboration with the HSG in the last 2 years.

The IUCN SSC HSG is hosted by:

Wildlife Reserves Singapore Group

