PROCEEDINGS OF THE 6TH INTERNATIONAL HORNBILL CONFERENCE
MANILA, 24 - 26 APRIL 2013

HORNBILLS AND CARING COMMUNITIES: HELPING FORESTS TO THRIVE

WILLEM VAN DE VEN, CHLOE TAN & YEAP CHIN AIK (EDS.)

WILD BIRD CLUB OF THE PHILIPPINES
HORNBILL RESEARCH FOUNDATION
PHILIPPINES BIODIVERSITY CONSERVATION FOUNDATION INC.

The Malayan Nature Journal • Vol 67 Part 2 • June 2015

• Vol 67 Part 2
• June 2015
• KDN PP 1933/04/2013 {032226)
• ISSN (032226)

Publication of the
MALAYSIAN NATURE SOCIETY

The Malaysian Nature Society

FOREWORD
THE 6TH INTERNATIONAL HORNBILL CONFERENCE, MANILA
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This focus on a particular region of Asian hornbills is also in keeping with the strong representation of Asian delegates at the conference, since most of the other threatened hornbill species also occur in Asia (one Endangered, six Vulnerable, 11 Near Threatened), with the exception of three Vulnerable African species of which only the Southern Ground Hornbill was discussed by an American and the only two African delegates. Understandably, such a continental imbalance in concern about hornbill conservation is also reflected in the venues of conferences past (thrice in Thailand and once each in South Africa, Singapore and Philippines respectively) and future (Malaysia), with the Indian subcontinent an obvious candidate for later.

All species of Asian hornbills are rainforest-dwelling species and, since rainforests generally occur in warm, moist and productive habitats, these areas also support dense human populations. Asian rainforests occur mostly in patches, spread across continental areas and especially across the various chains of islands and peninsulae in the region. This makes the forests and their hornbills especially vulnerable to developmental pressures, most obviously so on the scattered and relatively small islands of the densely populated Philippines. In contrast, African hornbill species all occur on a single landmass, with most species spread across several countries, but even here it is among the rainforest species that most endangerment is emerging.

The 13 full papers included in this conference proceedings cover, between them, national assessments (2), local studies of particular species (5), novel regional conservation approaches (3), in and ex situ management skills (2) and particular threats (1).

Hopefully, all these efforts will stem the strong tides flowing against hornbills, especially in rainforests and mainly in Asia. Hornbills are spectacular and emblematic birds, deserving of our protection, their evolution and classification are now more comprehensively understood than for any other avian group, and innovative conservation approaches are continually being developed to redress their decline. May this conference's proceedings further accelerate their conservation, so that by the next conference in Sarawak we can report even more progress.

ALAN KEMP
Pretoria, South Africa
February 2014

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Malayan Nature Journal
Volume 67(2) June 2015

Printed by United Selangor Press, Kuala Lumpur, Malaysia
KDN PP 1933/04/2013 - ISSN (032226)

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ALAN KEMP
Pretoria, South Africa
February 2014

An assessment on artificial nest construction for hornbills in Budo-Sungai Padi National Park, Thailand

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Abstract: A total of 19 artificial nests were installed in Budo-Sungai Padi National Park, southern Thailand, in 2004. These nests were constructed by hand from fiber reinforced plastic and insulated with poly-urethane foam. Since 2006, the number of artificial nests that have been used by hornbills has increased continuously. The aim of this study was to determine the suitability of the artificial nests by comparing hornbill nesting behaviour between artificial nests and natural nests. Hornbills had similar behaviours both in natural and artificial nests: hornbill visiting frequencies during nest visiting period, which is the period in which they select nests, for artificial nests and natural nests were 2.16 times/12 hours ± 1.27 SD and 1.35 times/12 hours ± 1.00 SD, respectively; visiting durations for artificial nests and natural nests during nesting periods were 7.21 minute/time ± 6.95 SD and 8.09 minute/time ± 7.19 SD, respectively; and nesting duration for artificial nests and natural nests were 121.3 days ± 4.16 SD and 122.6 days ± 15.7 SD, respectively. Microclimates of both natural and artificial nests indicated that the natural nests have better temperature and humidity control capability than the artificial nests. Artificial nests are a successful tool to increase the number of suitable nest cavities for wild Great Hornbills.

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Keywords: hornbills, nest boxes, artificial n ests, conservation, Thailand, Great Hornbill, *Buceros*

INTRODUCTION

Hornbills are large tropical forest birds; the largest species may reach 1.5 m long with a wingspan up to 2 m. They include some 57 living species, of which 12 are native to Thailand. Hornbills are well known for their unique nesting habits. Although hornbills nest in cavities, usually in large trees, they cannot excavate their own nest holes. They must use existing cavities in trees as nest sites.

A study of hornbills by Poonswad (1995) indicates that the availability of nesting cavities of appropriate size may be the most important population limiting factor. Hornbills nest only in cavities that suit the requirements of their breeding behaviour. Since hornbills are large birds, they need large nesting cavities that exist naturally only in large trees. Most nesting holes of hornbills occur in trees of the genus *Dipterocarpus* (Poonswad 1995), which are in great demand as the principal source of timber production in Thailand (Poonswad 1993). Hence logging is a main factor that seriously reduces both potential nest trees and suitable cavities.

The aim of the first part of this study was to explore the feasibility of using artificial nests as a means for hornbill conservation as well as to develop techniques for the practical use of artificial nests. The second part of this study assessed the suitability of the artificial nests by comparing them with natural nests using hornbill nesting behaviour as a criteria.

MATERIALS AND METHODS

Study site

Budo-Sungai Padi National Park is situated in Narathiwat Province, southern Thailand (Figure 1). The park has an area of 341 km^2 and covers parts of Narathiwat, Yala and Pattani provinces. It comprises of the Budo and Sungai Padi mountain ranges, which are forest patches separated and surrounded by human settlements and agricultural lands. This forest is part of the Indo-Malayan tropical region which supports a Malaysian or Sundaic flora (Poonswad 2005).

The study site has steep terrain (56% of the area having about 30% slope), and lies between 100 and 1,182 m asl (Royal Thai Survey Department 1981). The Budo mountain range supports six species of hornbills: the Great *Buceros bicornis*, Rhinoceros *B. rhinoceros*, Wreathed *Rhyticeros undulatus*, Helmeted *Rhinoplax vigil*, White-crowned *Berenicornis comatus* and Bushy-crested Hornbills *Anorrhinus galeritus*

(Poonswad 2005).

Research parameters

The suitability of artificial nests was determined based on the main hypothesis: if nest cavities are in suitable conditions and located in suitable habitat, nest selection by hornbills would not differ significantly from natural nests. This hypothesis attempts to explain the relationship between two variables: nest characters (independent) and selection of nest by hornbills (dependent). The independent variable was quantified as sub-parameters involving breeding behaviour and microclimate condition of nest interior. The sub-parameters for breeding behaviour are: nest visiting duration by hornbills in each breeding phase, length of each breeding phase and the whole breeding cycle, and the composition of nest sealing material. The sub-parameters for microclimate condition of nest interior are temperature and relative humidity (RH). The suitability of the artificial nest was determined by comparing the results between the artificial and natural nests. Unless otherwise stated, significance was recorded at the 5% level ($P < 0.05$).

Microclimate

Two parameters including temperature and humidity were monitored and recorded from three types of sample i.e. (1) inside a natural nest, (2) inside an artificial nest and (3) its surrounding environment (outside nest). In order to control the effect of the differences in environmental factors in the study, an artificial nest was installed beside a natural nest on the selected natural nest tree and temperature and RH were monitored and recorded at the same time within every interval by using three data loggers (Extech Model 42270); one was placed inside an artificial nest,one inside natural nest and another for ambient temperature and RH. Temperature and RH were continuously monitored every two-hour interval for six days.

RESULTS

Artificial nest design

The final design of the artificial nest is prototype 6 (Figure 2). The design direction for prototype 6 aimed to balance design criteria and production capability. This prototype was made from fiber reinforced plastic. The dimensions are 50 cm (length) x 50 cm (width) x 120 cm (height). A perching place is located at the left side of the nest entrance. Prototype 6 consists of six parts (four side faces, a roof and a base). All nest box parts were assembled bottom-up, and secured together with bolts. A total of 19 artificial nests were installed at the study site between 2005 and 2006.

Hornbill visits and use of artificial nests

In the first breeding season after the installation, one pair of hornbills was observed visiting an artificial nests. From the second year, the number of nests visited increased steadily (Table 1). No artificial nests were used by hornbills during the first year after installation. The first active nest box was recorded in the second year (Figure 3).

The Great Hornbill was the only species that used the artificial nests while Rhinoceros Hornbills frequently visited nest boxes but never used them. The number of nest boxes used by Great Hornbills steadily increased throughout the study period from 5.2% in 2006 to 29.91% in 2009 (Table 1).

The percentage of nesting attempts in natural nests was higher than in artificial nests in 2008, but lower than artificial nests in 2009 (Table 2). In 2008, 33.33% of all natural hornbill nests and 17.64% of all artificial nests were occupied by Great Hornbills. In 2009, 23.8% of all natural nests and 29.91% of all artificial nests were occupied. (It should be noted that in late 2008, some unsuitable natural nests had been modified by the Thailand Hornbill Project teams, so the total number of suitable natural nests in 2009 were more than in 2008 breeding season. This caused the usage rate in 2009 to decrease slightly. If modified natural nests are excluded, the percentage use in 2009 is 27.77%.). So the rate of natural nests use from 2008–2009 decreased (9.53%, Table 2) but for artificial nests the rate increased (13.33%, Table 1).

Microclimate

Temperatures inside artificial nests were similar to the ambient temperatures (Figure 4). The highest temperature (28 - 29^{o}C) occurred from 1400 - 1500 hours. Lowest temperatures were recorded between 0300 - 0500 hours (22^{o}C, Table 3, Figure 4). Temperatures inside natural nests fluctuated less than the ambient temperatures, with conditions in the nest remaining stable (maximum of 1^{o}C temperature fluctuations).

The paired comparison (Post Hoc Tests) indicates that the temperatures recorded from both the artificial nest and ambient were similar while the temperatures recorded from the natural nest in both day and night were significantly different (Table 5).

The humidity inside artificial nests was similar to the ambient levels (Figure 4). During the day, RH recorded from both environments decreased at noon and increased at night. The lowest RH, about 81-82% occurred at 1400-1500 hours and the highest humidity, 92-93% occurred at 0400-0500 hours (Table 3, Figure 5). The RH inside the natural nest remained constant. Differences in humidity inside natural cavity between day and night was not more than 1-2%. During the day, RH inside the

natural nest differed significantly from ambient conditions, as well as conditions within the artificial nest (Table 4).

The humidity recorded during night time was more stable than daytime (Figure 4). During the day, RH in the artificial nest was similar to both the natural nest and ambient, while humidity recorded from the natural nest was significantly different from outside (Table 5). During night however, RH were compared, they can be arranged in decreasing order as follows: outside (93.4 ± 3.51), artificial nest (91.62 ± 4.95), and natural nest (91.002 ± 2.86) (Table 3). So it is possible that means of humidity recorded from all three environments were relatively similar with only 1-2% difference.

Temperature and RH recorded from both environments and the artificial nest were negatively correlated within and between groups (Table 6). In addition, the correlation between temperature and humidity recorded from inside the natural cavity was different from the temperature and humidity recorded from the above two environments because they are positively correlated within the group (Pearson's correlation = 0.871, P = .000). The temperature recorded inside the natural nest is positively correlated with the ambient temperature (Pearson's correlation = 0.826, P = .001) but negatively correlated with outside (Pearson's correlation = -0.678, P = .015). The humidity inside the natural nest is also positively correlated with outside (Pearson's correlation = 0.674, P. = 0.016) but is not correlated with the outside humidity (Pearson's correlation = 0.674, P = 0.119). Natural nest have a better temperature and humidity control capability than the artificial nest.

Nesting phase duration

The average duration of the nesting period for both artificial nests and natural nests was similar. Nesting periods in natural nests lasted 121.3 ± 41.16 days (Table 7), and in artificial nests 122.6 ± 15.27 days (Table 8). This supports data collected previously for this species (114-134 days, Poonswad et al. 1987). Nesting durations in each breeding phase were not significantly different between these two types of nest (Mann-Whitney U-test, two-tailed: nest sealing, 0.487; female sealed in nest, 0.827) (Table 9).

Nest sealing material properties

Results from both chemical testing and visual inspection indicate that nest sealing materials from a natural nest and an artificial nest have both the same composition and properties (Table 10). Wood dust, pieces of wood, seeds of fruit and some food debris were nest sealing materials that could be identified by visual inspection. Chemical analysis indicated

the properties of nest sealing material from both artificial and natural nests were basic in nature, and the textire sandy loam. Percentages of organic matters of nest sealing material from both types of nest were high (24.6% for artificial nest and 25.8% for natural nest).

Visiting frequencies during nest visiting phase

Visiting frequencies at used artificial nests and used natural were significantly higher than at unused artificial nests (Tables 11,12 and 13). Hornbill visiting frequencies recorded from used artificial and used natural nests were similar (Table 14). Hornbills visited the nest that they would be using in that season about 1-2 times per day. A frequency lower than this suggests the nest would remain unused for the season (Table 14).

Visiting duration during the nesting phase

Mean visiting duration at artificial nests was not significantly different from natural nests (Table 15, 16 and 17; $P = 0.584$).

DISCUSSION

Artificial nest design

We recommended artificial nests to be installed in places that are shaded or only temporarily exposed to sunlight rather than exposing them directly to sunlight for most of the day. Artificial nests need to be installed for at least one year before hornbills start using them.

Microclimate

The temperature and humidity inside the natural nest recorded in this study are also very similar to that reported by Poonswad (1993). The stable microclimaste observed in natural nests is very hard to achieve in artificial nest designs tested in this study, unless other mechanical ways of controlling the microclimate condition are used. Although the artificial nest was less capable of controlling the temperature and humidity than the natural nest, the Great Hornbill successfully bred in the artificial nest.

Hornbill nesting behaviour and their reaction to both artificial nests and natural nests

Hornbill nesting behaviour and their reaction to both artificial nests and natural nests were similar in the entire breeding phase. The average visit duration recorded in this study (11 minutes) was shorter than those described in previous studies (12 minutes, Ouithavan 2005; 22 min

Sukanya 2005).

The nesting duration of hornbills recorded from both artificial nests and natural nests were similar in both nest sealing period and imprisoned period with mean of eight days for artificial nests and nine days for natural nests for nest sealing period, 121.3 days for artificial nests and 122.6 days for natural nests for imprisoned period. This supports data collected previously for this species (114-134 days, Poonswad et al. 1987).

At present, the rate of visiting artificial nests by hornbills has declined and most of nest boxes that had previously been visited by hornbills had by already been occupied. This seems to indicate that artificial nest use rate may be close to its highest point.

Artificial nest is a successful tool to increase the number of suitable nest cavities for wild Great Hornbills.

ACKNOWLEDGEMENTS

We thank the National Park, Wildlife and Plant Conservation Department for permission to conduct this study in Budo-Sungai Padi National Park. We are indebted to the Thailand Hornbill Project research teams and villagers in Pattani, Yala, and Narathiwat for their assistance in field work. This study has been supported by Silpakorn University, Thailand Hornbill Project and Swarovski. Results from this paper were presented at the 6th International Hornbill Conference at Manila, Philippines in 2013.

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Royal Thai Survey Department. 1981. Map (1:50,000) Sheet 5321IV and 5322IV.

Table 1. Numbers of installed artificial nests, broken artificial nests, total artificial nests available, nests that were visited by hornbills, and nests that were used by hornbills during 2005–2009.

Year	Installed artificial nests	Broken artificial nests	Total artificial nests available	Nests visited by hornbills	Nests used by hornbills
2005	11	–	11	1	–
2006	9	1	18	2	1
2007	–	1	17	4	1
2008	–	2	15	6	3
2009	–	–	15	3	5

Table 2. Number and percentage of used natural nests from 2008 to 2009.

Year	Nest modified	Total natural nests available	Used natural nests	
			Number of nest	Percentage (%) of total available nests
2008	-	18	6	33.33
2009	3	21	5	23.80

Table 3. Mean and SD. Numbers recorded from three environments.

Environment		Temperature		Humidity	
		Day (°C)	Night (°C)	Day (%)	Night (%)
Artificial nest	Mean	25.4	23.32	84.87	91.62
	SD	2.57	1.30	10.30	4.95
Outside	Mean	26.02	23.31	82.21	93.40
	SD	2.56	0.96	10.14	3.51
Natural nest	Mean	24.09	23.91	91.79	91.00
	SD	0.64	0.53	1.93	2.86

Table 4. The multiple comparison (Sig. level ≤ 0.05).

One-way ANOVA results	The multiple comparison of temperature recorded during day time				
	SS	df	MS	F	Sig
Between group	69.866	2	34.93	7.693	.001
Within group	476.80	105	4.54		
Total	546.67	107			
	The multiple comparison of temperature recorded during night time				
	SS	df	MS	F	Sig
Between group	8.60	2	4.30	4.416	.014
Within group	102.225	105	.974		
Total	110.855	107			

One-way ANOVA results	The multiple comparison of humidity recorded during day time				
	SS	df	MS	F	Sig
Between group	1760.40	2	880.20	12.39	.000
Within group	7454.605	105	70.996		
Total	9215.005	107			
	The multiple comparison of humidity recorded during night time				
	SS	df	MS	F	Sig
Between group	111.692	2	55.846	3.712	.028
Within group	1579.607	105	15.044		
Total	1691.299	107			

Table 5. Results of paired comparison (Post Hoc) of temperature and humidity recorded from the three environments (Sig. level ≤ 0.05).

Paired comparison (Post Hoc) of temperature recorded during daytime	**Mean difference**	**Std. error**	**Sig.**
Between artificial nest & natural nest	1.30556*	.50227	.029
Between artificial nest & outside	-.62500	.50227	.430
Between natural nest & outside	-1.93056*	.50227	.001

Paired comparison (Post Hoc) of temperature recorded during daytime	**Mean difference**	**Std. error**	**Sig.**
Between artificial nest & natural nest	-6.91389*	1.98601	.002
Between artificial nest & outside	2.66667	1.98601	.357
Between natural nest & outside	9.58056*	1.98601	.005

Paired comparison results (Post Hoc) of temperature recorded during daytime	**Mean difference**	**Std. error**	**Sig.**
Between artificial nest & natural nest	-.59722*	.23260	.031
Between artificial nest & outside	-1.77778	.23260	1.00
Between natural nest & outside	.6000*	.23260	.030

Paired comparison results (Post Hoc) of temperature recorded during daytime	**Mean difference**	**Std. error**	**Sig.**
Between artificial nest & natural nest	.62222	.91421	.775
Between artificial nest & outside	.00278	.91421	.131
Between natural nest & outside	-2.40*	.91421	.027

Table 6. Pearson's correlation test results of the microclimate data.

		Recorded from artificial nest		Recorded from outside		Recorded from natural nest	
		Temperature	**Relative humidity**	**Temperature**	**Relative humidity**	**Temperature**	**Relative humidity**
Recorded from artificial nest	Temperature	1.00					
	Relative humidity	-.979*	1.00				
Recorded from outside	Temperature	.940*	-.968*	1.00			
	Relative humidity	-.827*	.899*	-.965*	1.00		
Recorded from natural nest	Temperature	.930*	-.881*	.826*	-.678**	1.00	
	Relative humidity	.884*	-.724*	-.674**	-.475***	.871*	1.00

* Sig. ≤ .01 ** Sig. ≤ .05 *** Not Sig. > .05

Table 7. Hornbill nesting duration recorded from three artificial nests.

Artificial nest code	Nest sealing period (number of days)	Imprisoned period (number of days)	Total	Average	SD
2	~9	~109	~118	121.3	4.16
6	~9	~111	~120		
14	~6	~120	~126		

Table 8. Hornbill nesting duration reorded from three natural nests.

Artificial nest code	Nest sealing period (number of days)	Imprisoned period (number of days)	Total	Average	SD
GH82	~13	~115	~128	122.6	15.27
GH78	~7	~128	~135		
GH48	~9	~99	~108		

Table 9. Comparison of nesting durations between artificial nests and natural nests (Sig. level ≤ .05).

	Mann-Whitney U-test Asymp. Sig. (two-tailed)
Comparison of nest sealing duration between artificial nests and natural nests	.487
Comparison of imprisoned period between artificial nests and natural nests	.827

Table 10. Chemical analysis results of nest sealing materials.

Sample Type		**pH**	**Organic Matter (%)**	**Texture**
Artificial nest	Sealing material	7.90	24.62	Sandy loam
	Floor soil	7.40	27.71	-
Natural nest	Sealing material	7.72	25.76	Sandy loam
	Floor soil	7.53	28.45	-

Table 11. Observation results during nest visiting phase from used natural nests in 2009.

Nest code	**Observation duration (minutes)**	**Hornbill visiting frequency**	**Hornbill visiting frequency / 12 h (observed from 0600-1800 hours)**	**Mean**	**SD**
GH1	1280	2	2.25	1.35	1.00
GH61	1295	1	0.55		
GH74	1522	1	0.47		
GH38	1005	0	0		
GH82	1316	3	1.641		
GH78	1289	2	1.11		
GH33	3469	9	1.86		
GH23	488	2	2.95		

Table 12. Observation results during nest visiting phase from artificial nests that were not used by hornbill in 2009.

Nest code	Observation duration (minutes)	Hornbill visiting frequency	Hornbill visiting frequency / 12 h (observed from 0600-1800 hours)	Mean	SD
3	784	0	0	0.20	0.46
4	420	0	0		
8	656	0	0		
16	5774	3	0.37		
17	893	1	0.8		
18	591	1	1.21		
19	316	0	0		
20	214	0	0		

Table 13. Observation results during nest visiting phase from artificial nests that were used in 2009.

Nest code	Observation duration (minutes)	Hornbill visiting frequency	Hornbill visiting frequency / 12 h (observed from 0600-1800 hours)	Mean	SD
2	433	0	0	2.16	1.27
6	487	2	2.95		
9	413	2	2.57		
13	344	1	2.09		
14	1577	7	3.19		

Table 14. Comparison of hornbill visiting frequency per 12 h (Sig. level ≤ .05) between samples.

	Mann-Whitney U-test Asymp. Sig. (two-tailed)
Between used artificial nests and used natural nests	.186
Between used artificial nests and unused artificial nests	.028*
Between used natural nests and unused artificial nests	.021*

Table 15. Range, mean, mode, and SD of nest visiting duration observed during the 2009 breeding season.

Nest type	From female finished to female emergence				From female emergence to chick emergence				Entire nesting period		
	Range (min)	Mean	Mode / Frequency (min / % of total visited)	SD	Range (min)	Mean	Mode / Frequency (min / % of total visited)	SD	Mean	Mode / Frequency (min / % of total visited)	SD
Artificial (n = 3)	1-35	6.13	6.0/25.5	4.16	2-58	9.01	5.0/31.8	9.76	7.21	5.0/27.4	6.95
Natural (n = 3)	1-65	8.29	5.0/20.8	7.45	1-56	7.69	5.0/36.8	6.65	8.09	5.0/26.3	7.19

Table 16. Normality test results of nest visiting data (Sig. level < .05).

Kolmogorov-Smirnov test	Visiting duration recorded from artificial nest	Visiting duration recorded from natural nest
Sig. (two-tailed)	.000	.000

Table 17. Comparison of nest visiting duration between artificial nests and natural nests (Sig. level < 0.5).

Mann-Whitney U-test	Comparison of nest visiting duration between artificial nests and natural nests
Sig.(two-tailed)	.584

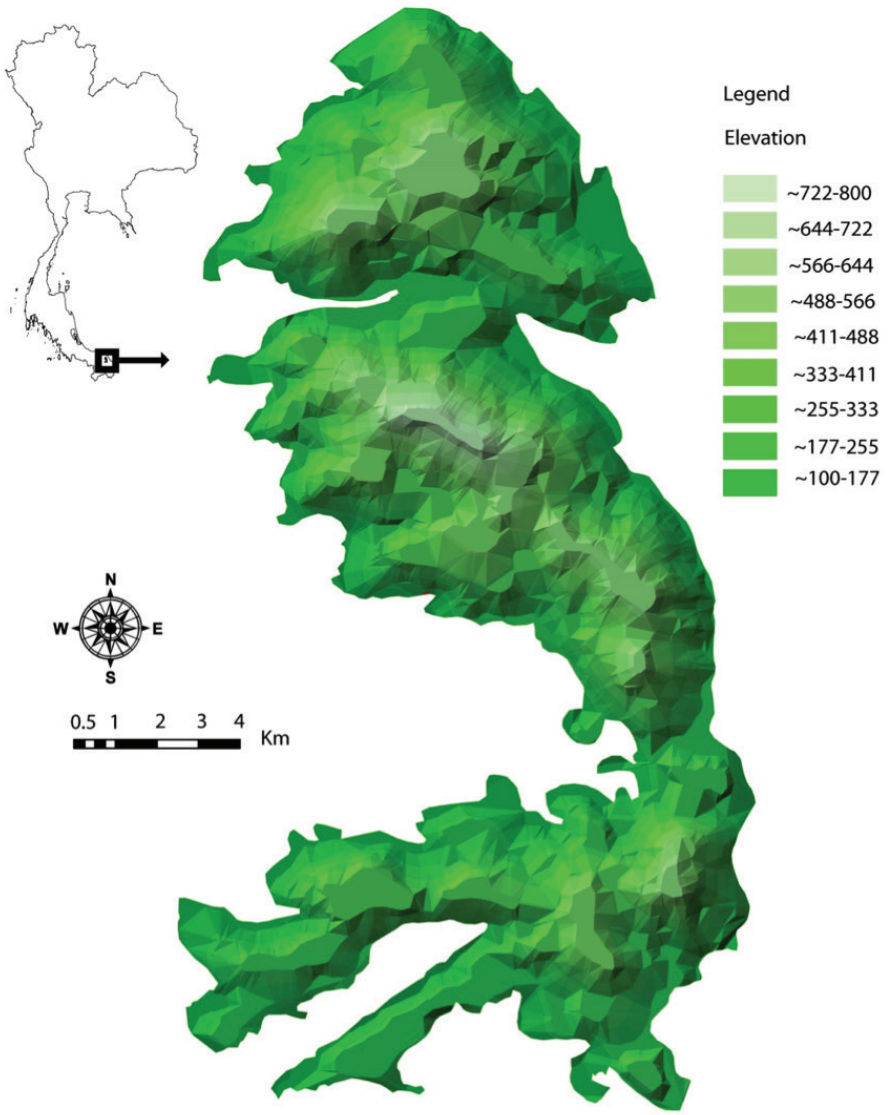
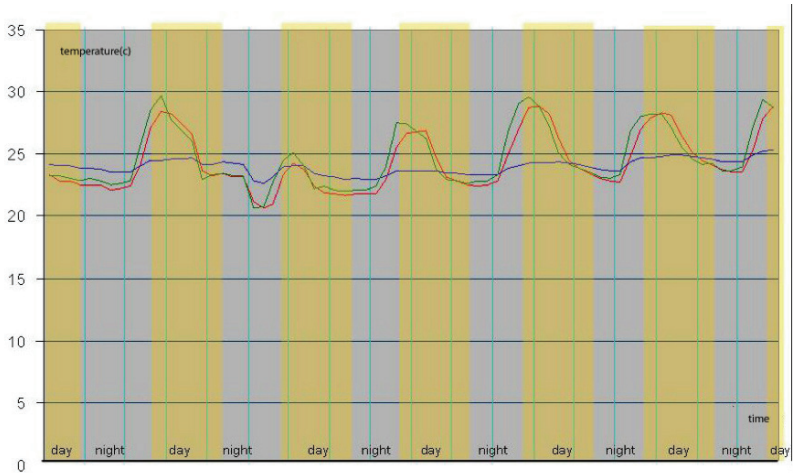


Figure 1. Budo Mountain Range.
[Source: Thailand Hornbill Project (2006) and land use data from Land Development Department, Ministry of Agriculture and Cooperatives, Thailand (2007)].

Figure 2. Artificial nest prototype 6.

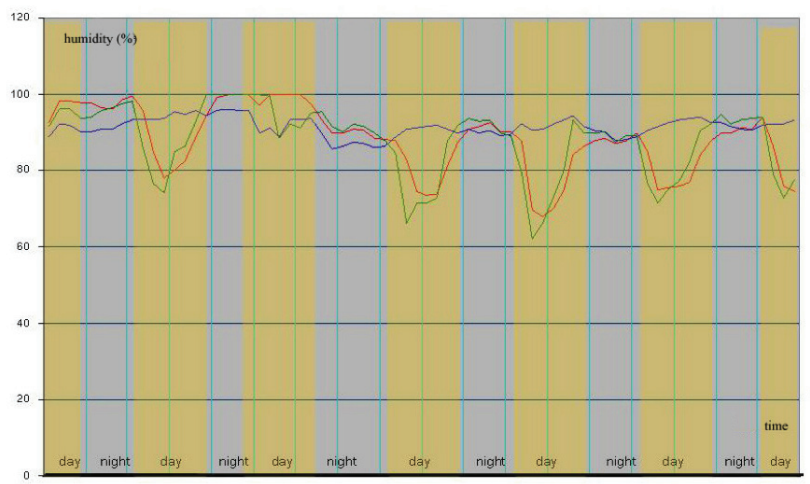
Figure 3. A male Great Hornbill at artificial nest No. 2.
(Photo credit: Ittipol Bauthong)



Legend

The temperature inside an artificial nest
Outside temperature
The temperature inside a natural nest

Figure 4. Temperature (°C) recorded from three environments; (1) outside nest, (2) inside a natural nest and (3) inside an artificial nest.



Legend

The humidity inside an artificial nest
Outside humidity
The humidity inside a natural nest

Figure 5. The humidity (%) recorded from three environments; (1) outside, (2) inside a natural nest and (3) inside an artificial nest.

Artificial incubation and hand rearing of Great Pied Hornbill *Buceros bicornis* following cannibalism of chicks by parents

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Abstract: : The Great Pied Hornbill *Buceros bicornis* also known as the Great Indian Hornbill, is one of the largest species of hornbill in the world. It is 93 - 129 cm long, has a wingspan of 152 cm and weighs from 2.15 - 4 kg. The species can be found in India, Indonesia, Malay Peninsula and Sumatra. It is listed as Near Threatened under the IUCN Red List of Threatened Species and the population is declining. This can be attributed to habitat destruction, mainly caused by logging and clearing of forests. They are also hunted for their casques which are kept or sold as trophies. At the Jurong Bird Park, a breeding pair of Great Pied Hornbill has successfully bred three times. During the breeding season in 2010, the female Great Pied Hornbill laid three eggs, but none of the three hatchlings survived as they were cannibalized. This was observed on infrared cameras used to monitor the birds. During the breeding season in 2011, because of its previous breeding history, three eggs were pulled out from the nest and artificially incubated at the "Breeding and Research Centre" at Jurong Bird Park. Two out of three eggs successfully hatched. The two chicks were hand raised and subsequently released into the "Hornbill and Toucan" exhibit. In 2012, another Great Pied Hornbill chick was removed from its nest and successfully hand-raised until it was weaned. Artificial incubation and hand-rearing of this species can contribute to higher breeding success in captivity.

Keywords: Great Pied Hornbill, *Buceros bicornis*, cannibalism, artificial incubation, Jurong Bird Par**k**

INTRODUCTION

The Great Pied Hornbill *Buceros bicornis* is one of the largest members of the hornbill family. It has a large, yellow and orange bill with a large, yellow casque (Tsuji and Poonswad 1996). During breeding season they are known to form monogamous bonds (del Hoyo et al. 2001). The remarkable nesting habit of the Great Pied Hornbill is such that the

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female seals herself inside the nest box leaving only a narrow opening for her mate to pass food to her, and later to the chicks (Kemp, 1995; Poonswad et al. 1998).

In the 40 years of Jurong Bird Park's history, hornbills have always played a very important part of its avian collection. Currently housing 17 species of hornbills, five of which are African, the park has accumulated a lot of data on breeding these magnificent birds.

In the hornbill breeding season of 2010, a pair of Great Pied Hornbills was monitored via CCTV cameras 24/7. This pair has been with us for the past 15 years. The provision of a suitable-sized aviary, suitable nutrition and artificial nest box design and careful observation resulted in the successful breeding of this species. Three eggs were laid, all of which hatched but were cannibalized by the parents.

In the breeding season of 2011, having learnt from the previous breeding season, three eggs were laid and pulled out after two weeks of incubation and transferred to the Breeding and Research Centre for artificial incubation and hand rearing (Figure 1).

In the breeding season of 2012, three eggs again were laid, of which one broke, one was infertile and one hatched. At around the tenth day of hatching, it was observed that the female stopped feeding the chick. Fearing the chick might die, it was pulled out and sent for hand rearing.

This paper reviews the methods, diet, incubation and feeding protocol of hand-raising the Great Pied Hornbill chicks.

BREEDING HISTORY AND CONDITIONS

Breeding season 2010

During the 2010 breeding season in Jurong Bird Park, data for Great Pied Hornbill breeding behaviour was recorded using CCTV cameras 24/7. On 3 February 2010, the female laid its first egg and on the 8 February, it laid its second egg (Figure 2A. Despite having laid two eggs, the female had yet to cease sealing the hole of the nest. The female spent most of her time incubating its eggs, turning them one at a time.

Since the morning of 14 February, the female Great Pied began ignoring her eggs; and left two of its eggs at the corner of its nest box (Figure 2B). This was worrying as the chances of hatching depend on the ability of parents to regulate the eggs' immediate environment within narrow limits. Thus, without the female incubating and turning the eggs, the embryos might die of uneven heat distribution or the growth of extra embryonic membranes and fluid dynamics might be retarded. On 15 February, the third egg was sighted (Figure 2C), bringing the clutch size to a total of three.

On 3 March, it was observed that the female hornbill was incubating all her eggs and none of them had hatched yet. According to del Hoyo et al. (2001), the incubation period is approximately 40 days. With that knowledge, the expected dates of hatching were gauged.

On 11 March, the first chick hatched, three days earlier than the expected date. The next day, at 1156 hours, tragedy struck when the female Great Pied ate its chick (Figure 2D). It was observed that the hatchling was still alive at 1102 hours, opening and closing its beak in a "calling out" motion. This indicates the hatchling was not a stillborn.

On 16 March, the second egg hatched, also three days before the expected hatch date. Thus, it seems like the incubation period for these birds in captivity is 37 days. The hatchling showed signs of movement, indicating it was not a stillborn. However, at 1429 hours, the male Great Pied stuck his head into the nest box and picked up the hatchling (despite attempts by the female to peck him out of the box), tossing and crushing it before offering it to the female (Figure 2E). The female accepted the offer from the male and ate its second hatchling (Figure 2F).

Three hours later, it was suspected that the female Great Pied Hornbill bit the head of the third hornbill hatchling and ate it (Figure 2G), as no egg was sighted from then onwards. Two days later, the female was observed throwing out an egg fragment.

Due to the cannibalistic events, which occurred in 2010, it was decided to pull out future eggs and artificially incubate them, then hand-rear the hornbill chicks to prevent infanticide.

The two adult hornbills were fed twice a day, once in the morning, at 0830 hours and once in the afternoon, at 1300 hours. The Great Pied Hornbill pair was fed a diet, which consists of papaya, bananas, grapes, minced meat, pinky mice and low iron hornbill pellet.

Breeding season 2011

The first egg was laid on 22 March 2011. The second egg was laid on 24 March. The hen naturally incubated the eggs for 14 days. On 4 April, a third egg was seen. Later that day, all eggs were removed from the nest box and submitted to the Breeding and Research Centre for artificial incubation. Through candling it was known that the first two eggs were fertile with active embryos, but the embryo in the second egg was weak. The third egg was fresh and still had no signs of development. The eggs were incubated in *Grumbach* incubators (Table 1), at a temperature of 36.9 - 37.2°C and at a relative humidity of 50 - 55%. The incubation period of a Great Pied Hornbill egg is about 38 - 40 days. Since the first two eggs had been incubated by the hen for 14 days, it was predicted that they should hatch in 24 - 26 days.

On 5 April, the third egg had no signs of blood vessels. The following day, a blood ring was present in the egg, indicating embryonic

death on the first stage of incubation. The first egg hatched on 14 April, and the second egg hatched on 20 April.

The two chicks were placed in *Brinsea* brooders in the nursery, which maintained a constant temperature of 37°C. Soft cotton towels were used as bedding. Before their first feeding, the two chicks were weighed. The first and second chick weighed 33.6 g and 34.4 g respectively. The chicks were weighed daily, every morning before the first feeding (Figure 3). They were fed 10 - 15% of their body weight. Their diet consisted of 60% papaya and 40% pinky mice, blanched in hot water. As they grew older, bananas, low iron softbill pellet, and mealworms were added to their diet. Nekton MSA was also added to their food to provide calcium and phosphorous, and *Duphalyte*. For the first four days, the chicks were fed seven times a day, starting from 0630 hours, each feeding spaced two hours apart. At eight days old, the bedding was changed to green matting to prevent leg splaying. Chicks were transferred to a wooden brooder once they were too big for the *Brinsea* brooders. Feeding was then reduced to five times a day, and then four times a day when the chicks were two weeks old. At Day 44, the feeding was reduced to three times a day. Both chicks had fairly constant weight gain. The first chick however gained more weight and was much heavier than the second chick. The first chick was then assumed to be male, while the smaller second chick was assumed to be female.

On 8 July, both chicks were sent to the avian hospital for endoscopy for sexing. The first chick was indeed a male, and the second chick was a female. There was a sharp decrease in the weight of the first chick from Day 62 to Day 84 (Figure 4). This decrease can be attributed to the weaning stage of the chick.

Development of the first chick (Andie):

Day 1, 14 April 2011	Chick was begging for food. It can move its head upwards and is able to gape.
Day 2, 15 April 2011	Stool of the chick was observed. No abnormalities.
Day 3, 16 April 2011	Chick is active, and begging for food.
Day 4, 17 April 2011	Maxilla is shorter than the mandible.
Day 5, 18 April 2011	Subcutaneous air sacs are observed on the neck, shoulders, legs, and abdomen. Egg tooth is present on the tip of the upper and lower beak.
Day 6, 19 April 2011	Chick begins to vocalize when it is hungry.
Day 7, 20 April 2011	Pinning in the tail observed.
Day 8, 21 April 2011	The color of the skin is yellowish. Dark colors appear on left wing. Tail feathers are beginning to emerge.
Day 9, 22 April 2011	Wing feathers started to grow. The left eye is

	beginning to open.
Day 11, 24 April 2011	Pin feathers begin to grow. Both eyes begin to open.
Day 15, 28 April 2011	Eyes are partially open.
Day 16, 29 April 2011	Appearance of dark color and black pin feathers on the chick's back.
Day 18, 1 May 2011	Egg tooth is absent on the lower mandible. Skin is darker in color.
Day 81, 3 July 2011	Chick fully fledged, able to fly. Chick is still not interested in picking up food.

Hand-rearing (chick pulled out)

In February 2012 (date unknown), the Great Pied Hornbill pair laid another egg. This time, the egg was not removed for artificial incubation so the parents could be given a chance to raise the chick by themselves. The mother diligently incubated the egg. On 10 March, the egg hatched. For the first six days, the mother was seen feeding the chick. However, on 15 March, the mother was observed to be ignoring the chick. Fearing that it would cannibalize the chick, it was decided to pull out the chick from the nest box and hand-raise it.

The chick was removed on 16 March in the afternoon, and placed in a *Brinsea* Brooder in the BRC Nursery. Upon admission, the chick weighed 115 g, and appeared healthy, although it was hungry. The chick was fed the same diet as the first two chicks. *Mazuri* Pellets and small pieces of minced meat were added to the diet, as there was a lack of supply of pinky mice. The same feeding protocol was applied to this chick. By comparing the weight gain of this chick to the first two chicks, we can conclude that it is most probably a female, as its weight gain is more similar to the weight gain of the second female chick.

When the chick was too big for the brooder on 25 April (Day 42), the chick was moved to a weaning room in the new BRC building. The room is heated with lamps to a temperature of about 29 - 32°C and humidity ranged from 50 - 70%, with the humidity being higher when the room was still slightly wet after cleaning.

Development of the third chick (Bella; Figure 5):

Day 7, 16 March 2012	Chick is observed begging for food and will gape. Stool appears normal.
Day 11, 21 March 2012	Left eye of chick is open. The right eye is partially open.
Day 15, 25 March 2012	Both eyes are fully open. Pin feathers observed on the abdomen.
Day 23, 2 April 2012	Primary and secondary pinning. Eyelashes have started growing.

Day 32, 11 April 2012	Feathers growing on the wing and tail.
Day 46, 25 April 2012	Chick is able to hop.
Day 55, 4 May 2012	Feathers growing on the back of the chick.
Day 73, 21 May 2012	Chick jumps and flaps its wings when begging for food. Chick is able to perch, but will rarely do so.
Day 76, 25 May 2012	Ventral part of the neck is covered with white feathers.

OBSERVATIONS AND DISCUSSION

Certain behaviours demonstrated by Great Pied Hornbill chicks make them somewhat of a challenge to raise. When hornbill chicks reach a certain age (around 40 days), their feeding behaviour changes (Figure 6). This was observed in all three chicks that we hand-raised. At first all of them responded well to the diet provided to them. Once they were older, they began rejecting food given to them. Sometimes the chicks would accept the food as usual, but sometimes they would reject and even regurgitate it. One must take note of this behaviour and ensure the chicks have received sufficient food. The chicks have been observed to regurgitate their food several minutes after being fed, hence one must constantly observe the chicks, especially after feeding. This behaviour is not an indication of poor health, but rather the chick being more aware of its environment and thus being pickier of the food given to it. At this stage, the chicks appeared to mainly reject fruits, and seem to only want to eat meat, but this did not occur all the time. This behaviour may suggest that hornbill chicks require more protein at this stage, or that the chick simply prefers the taste of meat.

The first and second chicks only began showing interest in feeding on their own after they were fully fledged. The third chick however, began picking up food by itself on Day 47. Previously, the chick was fed using a spoon by pouring the food into its open beak. On Day 28, the chick, rather than opening its beak and begging for food, started grabbing pieces of food from the spoon and flinging it into its throat. It was imitating the feeding behaviour of adult hornbills. Forceps were used to feed the chick instead of a spoon. A food tray with slices of banana, papaya, and large mealworms were provided to encourage the chick to eat on its own. Three days later, during feeding in the morning, the chick was observed to be paying particular attention to the mealworms on the food tray. It then proceeded to pick up the mealworms and eat them on its own. The chick learned how to pick up pieces of papaya and banana after two days. Despite being able to eat on its own, the chick was not eating enough, so it was still hand-fed small amounts of food during each feeding, which at

the time was reduced to three times a day.

In the wild, when a female Great Pied Hornbill leaves its nest, the chicks will reseal the nest with pieces of food (Tsuji and Poonswad 1996) or feces. This behaviour was also observed in the hornbill chicks. The chicks will pick up pieces of food and smash them against a surface, in the third chick's case the side of a perch provided for it.

Male Great Pied Hornbill chicks are heavier than female chicks. By the ninth day, the male chick had a higher daily weight gain than the other two chicks. Despite the difference in size and weight, the anatomical developments of the chicks are similar.

ACKNOWLEDGMENTS

We would like to thank Muhammad Haziq Bin Rusli, Diploma in Veterinary Bioscience, School of Life Sciences and chemical technology, Ngee Ann Polytechnic for his support in hand raising the chicks; Gan Keng Tiong, for taking photographs; San Diego Zoo, for providing advice on diet and hand feeding protocol for the chicks; Avian Department for successfully breeding the Great Pied Hornbill pair; Jurong Bird Park management for supporting this project as part of the conservation program by the park.

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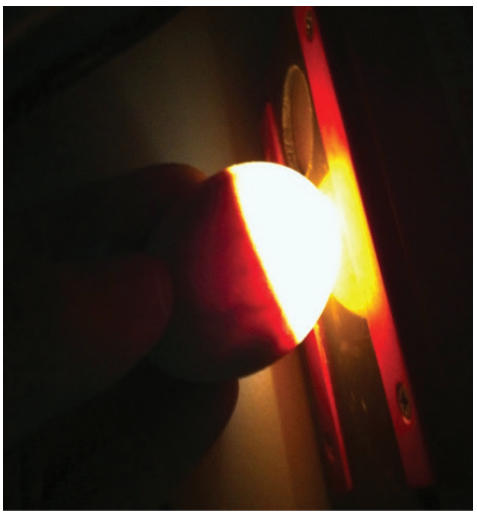
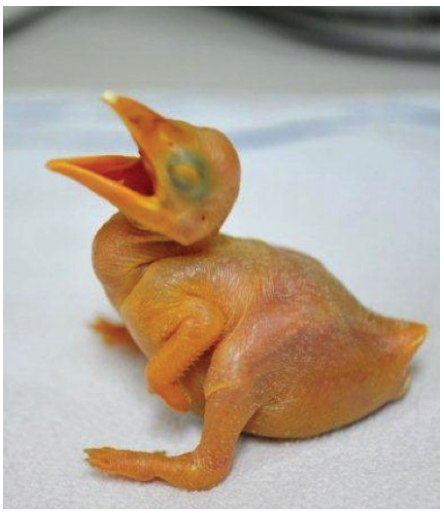
Table 1. Product information.

Grumbach	Grumbach® incubator – artificial incubators made up of high quality synthetic material which are easy to clean and disinfect. Temperature, humidity and egg turning can all be electronically programmed to suits the species you want to incubate.
Mazuri	Mazuri® low iron pellets – these are pellets designed especially for birds that are prone to hemochromatosis or irons storage disease. The iron content of these pellets are no less than 100 ppm.
Duphalyte	Duphalyte® an infusion fluid containing amino acids, vitamin, electrolytes for extra energy.
Brinsea	Brinsea® brooders – (TLC4) - Thermal life support cabinet for brooding parrots and other altricial bird species.



A. The first Great Pied Hornbill egg at 20 days of incubation.



B. The first Great Pied Hornbill chick which was artificially incubated at Jurong Bird Park's Breeding and Research Centre, begging for food at six days old.

C. The first pair of Great Pied Hornbill chicks hatched successfully after artificial incubation. The chick on the left is 25 days old while the chick on the right is 31 days old.

D. The third Great Pied Hornbill Chick at 48 days old. The chick is almost fully feathered, except for its neck and back, where pin feathers are still growing.

Figure 1. Development of Great Pied Hornbill chicks.

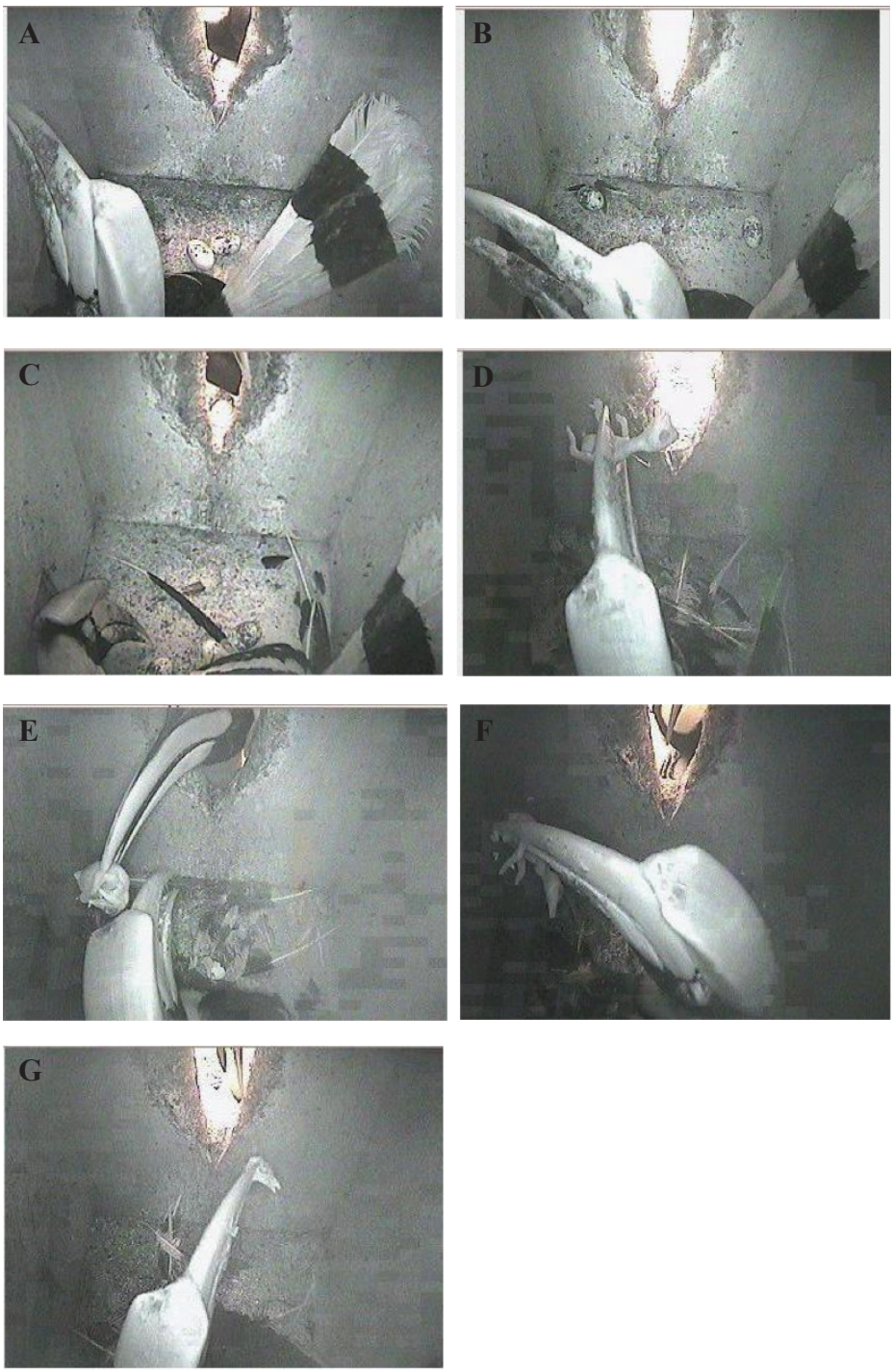


Figure 2. DVR recording inside the nest box of the Great Pied Hornbill pair, depicting the presence of three eggs and cannibalism of its chicks.

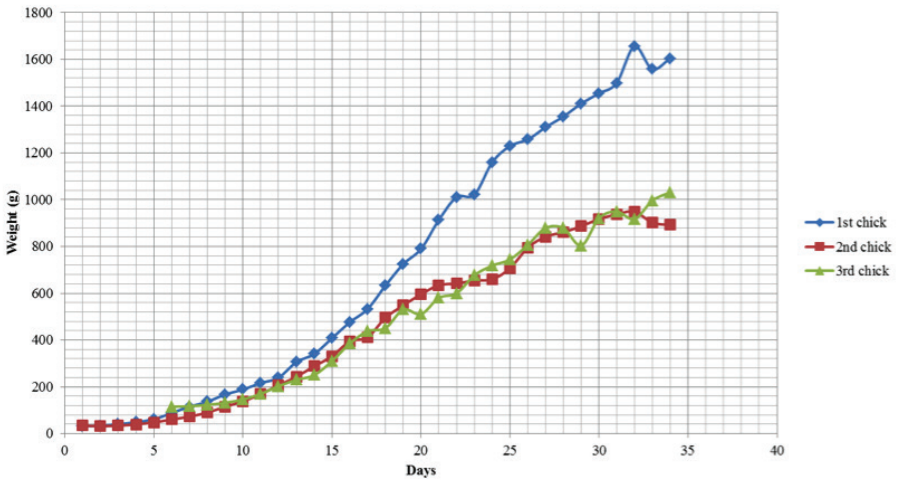


Figure 3. Comparison of weight of all Great Pied Hornbill chicks.

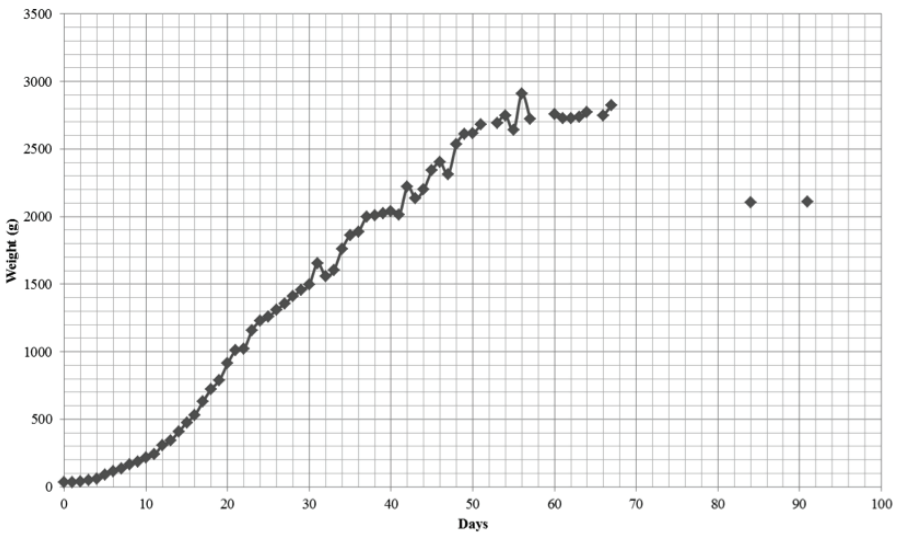


Figure 4. Weight of the first Great Pied Hornbill chick.

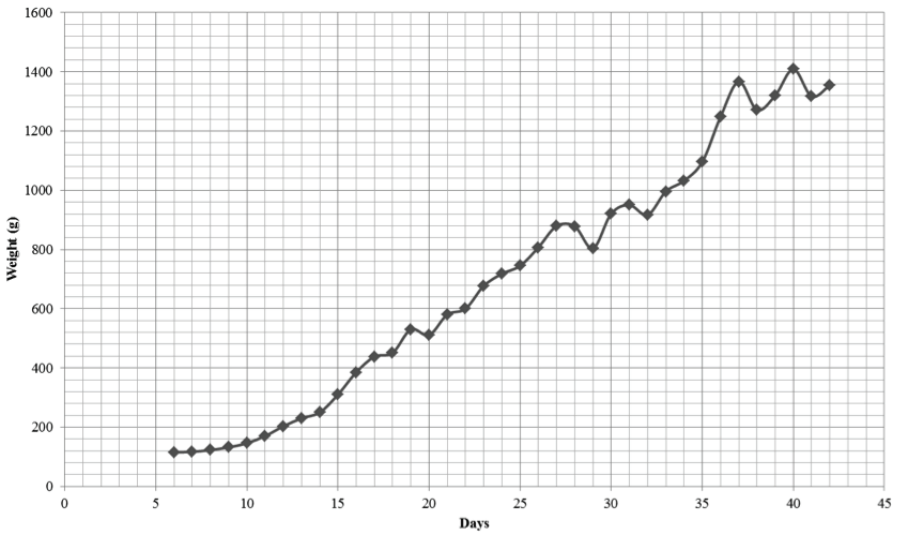


Figure 5. Weight of the third Great Pied Hornbill chick.

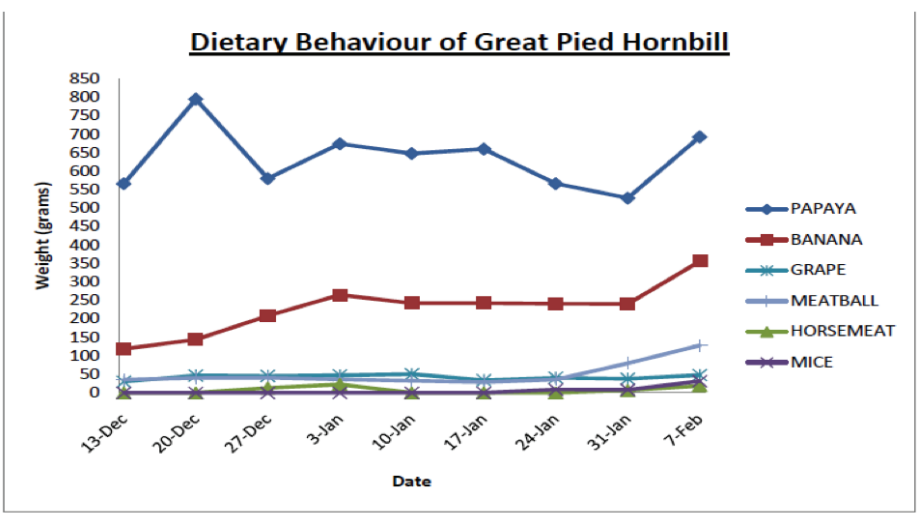


Figure 6. Dietary behaviour of Great Pied Hornbill chicks.

Aspects of breeding biology and conservation of the Palawan Hornbill *Anthracoceros marchei* in the Palawan Faunal Region, Philippines

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Abstract: Palawan Hornbills occur in three protected areas managed by Katala Foundation, Inc. (KFI), which was established primarily for the conservation of the Philippine Cockatoo *Cacatua haematuropygia* within the Palawan faunal region. Characteristics of nest habitats and nest trees are presented, which may aid habitat restoration efforts for the species. A total of nine nest trees, comprising eight species, were monitored within the cockatoo reserves. Nest trees were canopy-forming or emergent species. Breeding season on Dumaran Island lasted from approximately end of March to mid-July. Clutch size ranged from two to three eggs, with four on one occasion. The average number of chicks fledged was two, although in the nest with four eggs all four chicks fledged. Palawan Hornbills are apparently capable of withstanding a certain degree of habitat degradation. The species is able to forage in closed forests, forest-agricultural landscapes and mangroves, but persistent shifting cultivation, and more recently, mining, biofuel plantations and other larger scale projects, continually reduce suitable habitats. Hunting hornbills for bushmeat is an ongoing threat and almost certainly under-recorded. Nestlings are regularly poached for the pet trade, as indicated by occasional confiscations. In the past years the species has turned up sporadically in the domestic and international wildlife trade. The Palawan Hornbill benefits from the management of cockatoo reserves and forest rehabilitation implemented by KFI and particularly from the wildlife-warden schemes, which have been established at all project sites. Because of its role as seed disperser, the hornbill plays an important role in the forest ecosystem, which can be usefully promoted in conservation education activities.

Keywords: wildlife trade, bushmeat, Philippine Cockatoo, warden scheme, conservation education, Palawan Hornbill, *Anthracoceros marchei*

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INTRODUCTION

The Palawan Hornbill is the sole representative of its family in the Palawan Faunal Region of the Philippines (Kemp 1995). It has been recorded in most of the major islands in the archipelago, namely Palawan, Busuanga (including Calauit), Culion, and Bugsuk (Dickinson et al. 1991; Collar et al. 1999; Kennedy et al. 2000). More recently it has been recorded in Dumaran, Pandanan, and a number of smaller islands in the Bacuit Archipelago. The species is absent from smaller satellite islands in the Sulu Sea, particularly in Honda Bay, Malinau, Aborlan and Rasa Island, Narra (KFI, unpubl. data). The Palawan Hornbill occurs in lowland and hill forests up to circa 900 m asl (BirdLife International 2013) and occasionally enters cultivated areas (Collar et al. 1999). Due to the rapid decline of forests, particularly in the lowlands and because of continued hunting and trapping pressures, the species is currently listed as "Vulnerable" (IUCN 2013).

Very little information on the breeding biology has been published, other than a specimen that was collected from Napsan in the month of April that had enlarged testes, and "… it breeds in the same trees as the Philippine Cockatoo *Cacatua haematuropygia*" (Collar et al. 1999). The species benefits from a nest protection scheme implemented by KFI as part of the Philippine Cockatoo Conservation Programme (PCCP) (Kinnaird and O'Brien 2007). In the framework of this programme, information on the breeding of cavity nesting birds is routinely collected, with priority given to the Philippine Cockatoo and two other parrot species. Therefore data sets for the Palawan Hornbill are not yet complete, but given the paucity of information for this species, particularly in respect to breeding biology, we decided to present new quantitative, though still incomplete, information on nest trees and nest sites, as well as on clutch sizes and nestling survival rates. Since data were gathered in the framework of a community-based warden scheme, often involving people with little experience with hornbills, we attempted to keep disturbance of nests to a minimum. As such, other aspects of breeding biology of Palawan Hornbill, like feeding intervals at the nest, duration of incubation and nestling development were not systematically investigated.

MATERIALS AND METHODS

Nests of cavity nesters were searched for in all three project sites in the course of the wildlife warden scheme of the PCCP. Up to 53 criteria were recorded for the nest trees and their surrounding environment. Since data for hornbill nest sites are not yet complete, only basic measurements of nest trees and cavities are presented in this paper. Nest trees were

identified to the lowest taxonomic level possible, sometimes with the help of herbarium specimens. Height of trees and nest holes were measured with clinometers. Dimensions of nest cavities were measured with metric tapes and tree diameters with tapes at breast height (1.3 m) or above buttresses. Nest trees were monitored during the breeding season in the course of other patrolling or research activities. Behavioral observations on active nest trees were made opportunistically.

Information on threats were collected over many years at the project sites and in other areas of Palawan through personal observations of habitat destruction and degradation, trade and hunting as indicated by confiscation, ethno-zoological interviews and screening of websites offering the species for sale and from records of the Department of Environment and Natural Resources (for confiscations within Palawan and export permits issued for the Palawan Hornbill).

The PCCP aims to be comprehensive in its conservation approach; its main components are a warden scheme employing ex-poachers, protected area management, conservation education employing the Pride methodology, which applies social marketing strategies to conservation education as well as law enforcement and advocacy, forest rehabilitation (with an aim for restoration) and applied research (Widmann and Widmann, 2008, 2011; Widmann et al. 2006). We assess how the Palawan Hornbill benefits from these activities and how it can be included in the overall conservation strategy.

Study sites

We collected data from the three project sites of the PCCP which contain populations of Palawan Hornbills (Figure 1).

- Omoi and Manambaling Cockatoo Reserves, Dumaran: Dumaran Island is situated in northeastern Palawan (10°22' - 10°41'N 119°28' - 119°55'E). The terrain of the island is rolling with the highest elevation reaching only 120 m asl. No permanent river systems or lentic water bodies exist. Only few small and isolated forest patches remain, none of them larger than 103 ha (Omoi Cockatoo Reserve). Manambaling Cockatoo Reserve covers 50 ha. The two reserves are dominated by evergreen and semi-evergreen lowland forest with Ipil *Intsia bijuga* and Amugis *Koordersiodenron pinnatum* representing emergent tree species of commercial value. Currently, reforestation efforts are under way for the buffer zones and a corridor connecting the two reserves. The main forms of land use are upland slash-and-burn agriculture ('*kaingin*'), which is still widespread. As a consequence of this practice a large part of the island is covered by grass, shrubs and dense stands of bamboo. Permanent forms of cultivation are coconut and cashew plantations. Forest and grass fires are common, particularly during the dry season. Illegal logging is widespread.

- Culasian Managed Resource Protected Area (CMRPA), Rizal: This protected area (8°52' - 8°47' N 117°27' - 117°31'E) is situated in the coastal plain facing the South China Sea. It covers an area of 1,954 ha. CMRPA ranges from sea level to approximately 140 m asl. The terrain is flat in the narrow coastal area and rolling to moderately steep in the remaining portions. Two permanent rivers mark the periphery of CMRPA: Culasian River in the north and Arapitan River in the south. Smaller ephemeral creeks and stagnant water bodies can be found inside the area. The major terrestrial ecosystem in the protected area is lowland dipterocarp forest. Forest canopies often reach 30-40 m. *Dipterocarpus grandiflorus* and *Koompassia excelsa* are the most conspicuous emergent tree species, with the latter reaching more than 70 m in height. Other emergent species include *Dipterocarpus gracilis, Dipterocarpus hasseltii, Intsia bijuga* and *Koordersiodendron pinnatum*. Flat and rolling areas are dominated by permanent cultivation, mostly irrigated and rain-fed rice paddies, coconut plantation and pastures. Shifting cultivation is most common along the roads, but can frequently be found isolated in forested areas, often on steep slopes. Emergent isolated trees in cultivated areas are nest sites of hornbills, parrots or mynas 'owned' individually by poachers ('poacher trees'), and therefore spared when the area was cleared.
- Pandanan Island, Balabac: Pandanan is one of the smaller islands within the Balabac Group situated at the southern tip of mainland Palawan. Coastal forests are dense and grow on flat limestone originating from elevated coral reefs. Large trees in the coastal forest are mostly deciduous and widely spaced due to water stress during the dry season. The understory is very dense with abundant vines. Emergent trees comprise the genera *Dipterocarpus, Pometia* and *Ficus*. A narrow rim of beach forest with *Erythrina, Calophyllum* and *Barringtonia* is present. The dense coastal forest cover is well protected because a large portion of the island is privately-owned and visitors are monitored by private guards. Coconuts are the major crop in the coastal areas and shifting cultivation including lowland rice, corn and root crops inside forested areas are common land use forms.

RESULTS AND DISCUSSION

Breeding biology

We monitored nine nest trees comprising eight species, of which five were identified to species level and two to genus. One dead nest tree without leaves or bark remains unidentified (Table 1). At least four trees (*Azadirachta, Koompassia, Pongamia, Terminalia*) are very tall and are regularly present as emergents. These species are also utilized by other

cavity nesting species in Palawan, particularly Philippine Cockatoos, Blue-naped Parrots *Tanyganthus lucionensis*, and Hill Myna *Gracula religiosa*. Of these, *Koompassia excelsa* has long been considered the tallest rainforest tree species (Whitmore 1972). Within the Philippines it is restricted to the southern portion of Palawan where it plays a major role for cavity nesters and bird poachers alike (Orbeta 2004). The remaining three species were canopy-forming.

Average tree height was 43.4 m (15-70 m; n = 5), average diameter 110 cm (41-143 cm; n = 5). The two *Koompassia* nest trees were solitary within old shifting cultivation areas in CMRPA, the *Cleistocalyx* was situated at the forest edge and the remaining trees were within closed forest. Two nest trees were dead (22%), whereas six appeared to be healthy (78%). The average height of nest holes was 30.2 m (9-56 m; n = 5). Nest cavities in six trees were situated on the main trunk (67%) and in three trees on leading branches (33%). Nest cavity dimensions were on average 49 cm (37-69 cm; n = 3) high and 24 cm at the widest point (18-33 cm; n = 3). The large size classes of nest trees recorded are certainly due to the fact that sampling size was small and included two very tall *Koompassia*.

The breeding season for Palawan Hornbills in Dumaran spans from the last quarter of the dry season (end of March) to the middle of the rainy season (end of July). The same nest trees were used over a number of years, with the longest recorded period being five consecutive years. One female was observed to seal nest entrance from outside and later from inside, using orange-coloured fruit pulp containing very small seeds (possibly *Ficus*). Timing of egg-laying after sealing of the nest hole is not known. Clutches of monitored breeding attempts consisted of two (n = 6), three (n = 2) or four eggs (n = 1) (Figure 2). Survival rate of nestlings to fledging stage was 82% in 12 nesting attempts. One observed cause of breeding failure was the collapse of a nesting tree, killing the female and two nestlings.

Exact incubation and nestling periods could not be observed, but are estimated respectively to be around 28 and more than 50 days. Food items brought to the nest by the male included fruits, an Emerald Tree Skink *Lamprolepis smaragdina*, and other unidentified lizards. A midden was noted to have seeds of at least 13 species, of which four genera could be identified: *Syzygium, Canarium, Eleocarpus* and *Garcinia*.

Threats

The core habitat of the Palawan Hornbill is old-growth dry lowland and hill forest, where the highest population densities were recorded, whereas the species was not recorded in cultivated areas (Mallari et al. 2011). However, in Dumaran and Rizal the species was regularly encountered in tree-dominated agricultural areas (fruit orchards, shifting cultivation with remnant “poacher trees”); if suitable nest trees exist,

breeding occurs in these semi-open areas. We suspect that nest trees may be the limiting factors in these largely human-influenced systems, since large and potentially suitable trees are usually cleared to make way for agriculture, or logged for timber or firewood.

Palawan in its entirety has been declared a Biosphere Reserve (UNESCO's Man and Biosphere Programme), though lowland forest is still declining. Due to the unique provisions of the Strategic Environmental Plan for Palawan, the least protected forests are the most diverse lowland forests, which are also most valuable for the Palawan Hornbill and other cavity nesters. However, even demarcated core and restricted use zone forests are occasionally declassified for other uses by the Palawan Council for Sustainable Development. Reasons for forest loss include shifting cultivation and illegal logging, but increasingly also large-scale projects, including mining and biofuel plantations (Lasmarias 2004; Orbeta 2004), and possibly also infrastructure projects related to tourism.

The species is traditionally hunted for food, like most other hornbill species in the Philippines (Gonzalez 2011), but quantitative information is mostly anecdotal and overall effects on the population are unknown. Fifty hunters interviewed in Rizal, southern Palawan, stated that they took 17 hornbills in one year, of which 14 were meant for their own consumption. However, almost all declared that they use bushmeat occasionally for bartering (Villafuerte-van den Beukel et al. 2009). If these figures could be confirmed for other regions of Palawan, then hunting for food would have a much higher impact on hornbill population compared to the pet trade. Adult birds are usually shot with air-guns or home-made front-loader guns, whereas chicks and incubating females are taken from nests. Palawan Hornbill meat, like other bushmeat, is popular as snack ("*pulutan*") accompanying drinking sessions.

Palawan Hornbills are occasionally traded as pets domestically and internationally. Seventeen wildlife traders have been identified from southern Palawan alone, and between 2000 and 2006 a total of 38 birds were confiscated in this province (Cruz et al. 2009) (Figure 3). However, since no indicators for law-enforcement or poaching efforts are available, no clear trend in trade can be extracted from the data. Internet searches revealed that the species is occasionally offered for sale online. Particularly, offers from domestic trade platforms like sulit.com should be thoroughly scrutinized, since they almost certainly include illegally acquired animals. A zoo in Novosibirsk, Russian Federation, acquired a young pair of Palawan Hornbills in 2012 from unknown sources (R. Wirth in litt. December 2012). The Department of Environment and Natural Resources issued export permits for 19 Palawan Hornbills from two facilities in Manila between 2008 and 2013 (DENR-PAWB in litt. April 2013), but no permit was issued to the zoo in Novosibirsk.

Conservation

The Palawan Hornbill is present in a number of protected areas, most importantly El Nido-Taytay Managed Resource Protected Area, Puerto Princesa Subterranean River National Park and Mantalingahan Protected Landscape. The species is also recorded from three out of four sites managed under the Philippine Cockatoo Conservation Programme (study sites with breeding records for the species). Due to its habitat requirements, all cockatoo reserves are situated in coastal areas, which are under immense pressure from human populations and therefore pose particular conservation challenges. Although these reserves are mostly small, ranging between 0.5 and 39 km^2 in area, they contain large percentages of Palawan's threatened vertebrate assemblages. In two of these cockatoo reserves, 60% of globally threatened terrestrial mammals and 67% of globally threatened bird species recorded for the island can be found. All sites benefit from community-based warden schemes. Wildlife wardens, mostly ex-poachers, patrol the areas and monitor wildlife populations, particularly cavity-nesting bird species. These schemes have the advantage of providing poachers with a legal source of income while immediately removing hunting and trapping pressure on wildlife population, as well as adding local knowledge to conservation efforts (Widmann et al. 2006). Cockatoo reserves are either privately or publicly owned, the latter are declared as protected areas on municipal or national levels. As a result of the warden scheme, no recorded hornbill nest tree in any of the cockatoo reserves was cut down or poached for birds since the start of the projects in 2002 and 2007 respectively.

Hunting and trapping of Palawan Hornbill in cockatoo reserves is addressed through the warden schemes as well. These have resulted in a number of confiscations, all from CRMPA and surrounding areas. However, none of these has ever led to prosecution of notorious traders, presumably because wildlife crime is not ranked very high on the agenda of local courts and some traders are politically well connected.

Due to the vicinity to human settlements, conservation education for coastal biodiversity is of utmost importance. KFI utilizes the Pride methodology employing social marketing strategies. The role of ecosystems and species for the welfare of people is highlighted; for example the protection of mangroves as nurseries for economically important fish and crustacean species, or the protection of riparian forest to prevent riverbank erosion. Although cockatoos can disperse seeds in certain circumstances, they do so over short distances, while destroying a very high percentage of these seeds. The Palawan Hornbill on the other hand is an effective seed disperser and is regularly used as an example of a species providing ecosystem services in conservation education campaigns. Consequently hornbills feature prominently in lectures, on posters, in puppet theatres or face-painting activities (Figure 4).

Rehabilitation of coastal forest areas is a strategy to increase potential habitat for flora and fauna of lowland forests in Palawan. For many years KFI has conducted experimental reforestation, testing performance of mostly native tree species in respect to survival rates and growth performance. Depending on the site conditions, assisted natural regeneration and/or enrichment planting methods are applied (Widmann and Widmann, 2011). Reforestation efforts have been focused in the buffer zones of the very small cockatoo reserves on Dumaran Island and one of the last remaining lowland dipterocarp forest patches stocking on limestone in the Sulu Sea coastal plain. In 2012, the creation of a forest corridor between two cockatoo reserves in Dumaran was initiated, which will eventually cover 256 ha. Among the propagated tree species are also six nest-providing and eight food-providing plants for hornbills. For some of the latter, seeds were collected from hornbill nest middens. Seeds acquired in this way could be directly propagated in tree nurseries, since most of them were still viable.

CONCLUSIONS

Given the conspicuousness of the Palawan Hornbill and the relatively easy accessibility of some of its habitats, it comes as a surprise that no studies devoted to this species have been conducted previously. Although its breeding biology seems to be similar in many aspects to other *Anthracoceros* species (Kemp 1995), intensive nest monitoring may fill the gaps in our knowledge of this species. Information on feeding biology, particularly on food plants, would have an added applied conservation value by increasing the number of species that could be incorporated in habitat rehabilitation schemes.

Systematic population estimates and nest counts at different altitudes may provide better estimates for the global population of the species. It may also lead to better informed management of forest areas in Palawan, since paradoxically highly diverse and threatened lowland forest are less well protected than the less diverse and more secure forests in higher altitudes. Forest areas with Palawan Hornbill populations would qualify as "core zones" under the Strategic Environmental Plan of Palawan and should be declared as such by the Palawan Council for Sustainable Development. Quantitative information on how Palawan Hornbill populations react to hunting and trapping would provide a more solid foundation to inform and mobilize law enforcers and prosecutors.

ACKNOWLEDGEMENTS

We thank the organizers from Wild Bird Club of the Philippines, Hornbill

Research Foundation, and Philippines Biodiversity Conservation Foundation for giving us the opportunity to present our findings during the 6th International Hornbill Conference. We are grateful to the Loro Parque Fundación (LPF), Tenerife, Spain to the Partner Donors: North of England Zoological Society/Zoological Gardens Chester (NEZS), Zoologische Gesellschaft für Arten- und Populationsschutz (ZGAP, incl. Fonds für Bedrohte Papageien and Strunden-Papageien-Stiftung), Conservation des Espèces et des Populations Animales (CEPA), ZooParc de Beauval and Conservation Association (Association Beauval Conservation et Recherche) for long-term support of the Philippine Cockatoo Conservation Programme, including associated flora and fauna.

We are indebted to our host communities in Dumaran, Rizal and Balabac, particularly members of the warden schemes and the local protected areas management councils for working together with us on the ground to achieve measurable conservation outcomes. The Department of Environment and Natural Resources, particularly the Protected Areas and Wildlife Bureau provide the mandate for the PCCP. We are particularly thankful to Ms. Josie de Leon for providing the export statistics for this paper. Dr. Roger Wilkinson, NEZS was of great help to improve on a former version of this paper, for which we would like to thank him.

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Table 1. Measurements of nest trees and nest cavities of Palawan Hornbill.

Tree species	Family	Tree height (m)	Tree DBH (cm)	Nest height (m)	Vertical cavity dimension (cm)	Horizontal cavity dimension (cm)
Azadirachta excelsa (*n* = 1)	Meliaceae	47	52	17	69	33
Cleistocalyx sp. (*n* = 1)	Myrtaceae	20	41	18	37	18
Koompassia excelsa (*n* = 2)	Fabaceae	67.5	128	53.5	-	-
Pongamia pinnata (*n* = 1)	Sapindaceae	15	76	9	41	22
Syzygium claviflorum	Myrtaceae	-	-	-	-	-
Syzygium sp.	Myrtaceae	-	-	-	-	-
Terminalia calamansanai	Combretaceae	-	-	-	-	-
Unidentified sp.	Unidentified	-	-	-	-	-

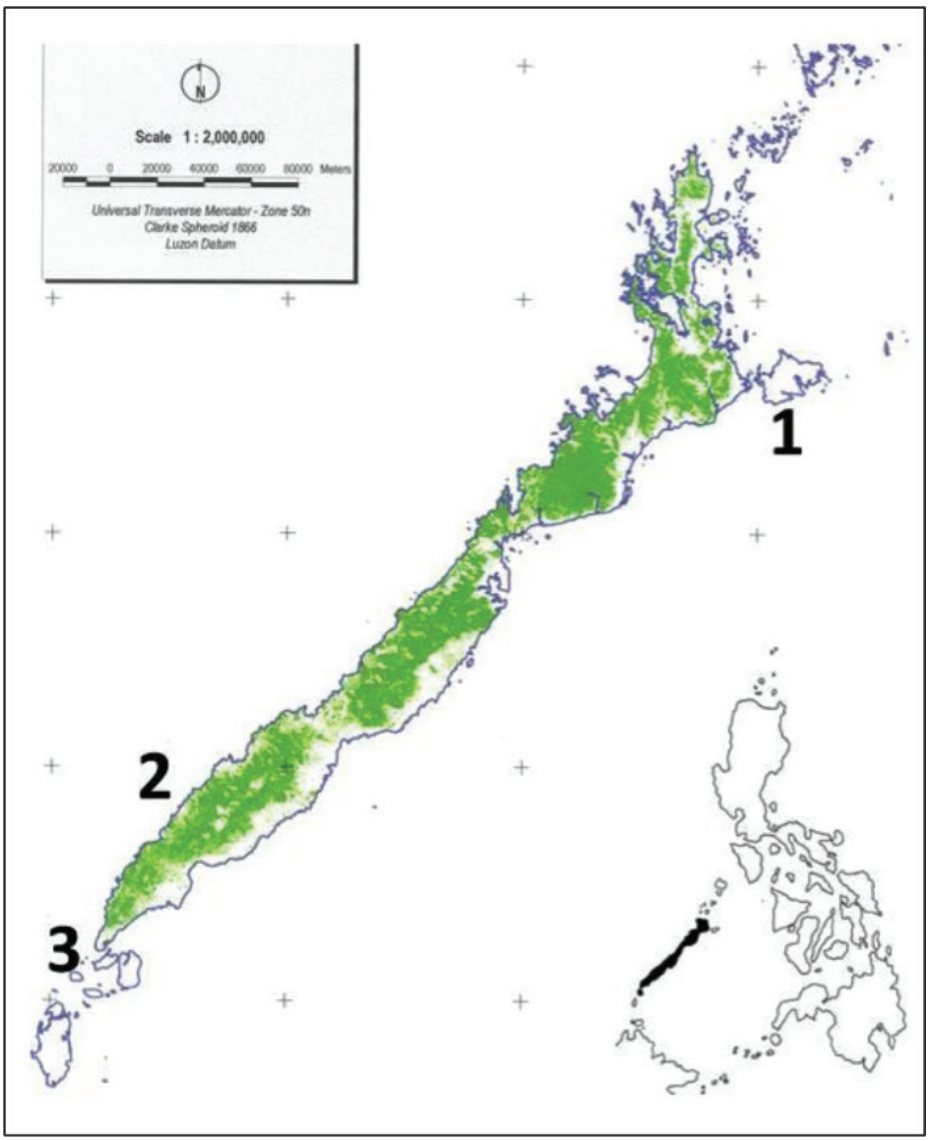

Figure 1: Forest cover (shaded) and location of study sites within Palawan: 1) Omoi and Manambaling Cockatoo Reserves, Dumaran, 2) Culasian Managed Resource Protected Area (CMRPA), Rizal, 3) Pandanan Island, Balabac. Inset: Location of Palawan within the Philippines (Map Source: Palawan Tropical Forestry Conservation Programme).

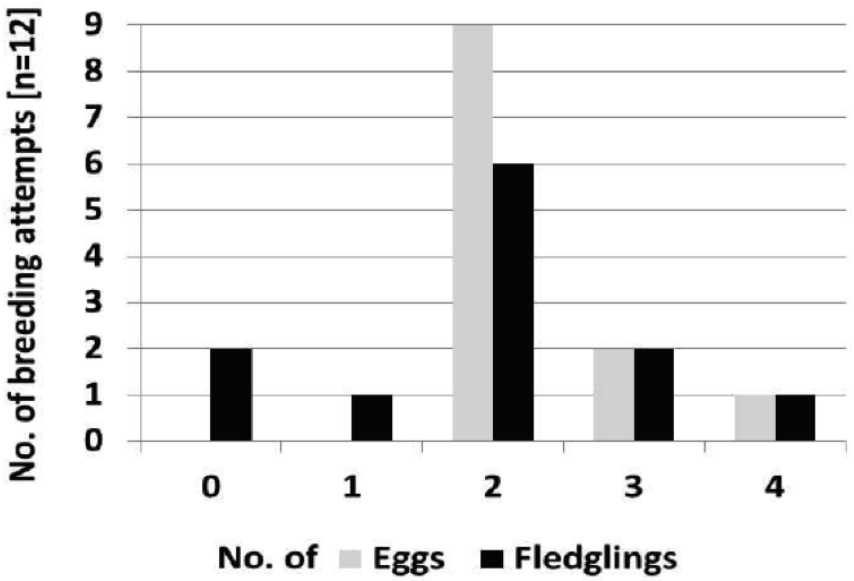

Figure 2: Clutch sizes and numbers of fledglings in relation to 12 breeding attempts of Palawan Hornbills.

Figure 3: Palawan Hornbill and Blue-naped Parrot nestlings confiscated from a wildlife trader in southern Palawan (Photo credit: KFI).

Figure 4: Palawan Hornbills are utilized in a number of methods for conservation education, including (above) face-painting and (below) puppet theaters. (Photo credits: KFI)

Conserving the globally threatened Plain-pouched Hornbills in the Belum-Temengor Forest Complex, Peninsular Malaysia

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Abstract: The globally threatened Plain-pouched Hornbill *Aceros subruficollis* is known to occur in only three countries *i.e.* Myanmar, Thailand and Peninsular Malaysia. In a recent assessment by BirdLife International, its global population is estimated to be between 1,500 and 7,000 mature individuals across its distribution range and is rapidly declining due to habitat loss and degradation and hunting. The occurrence of Plain-pouched Hornbills in Peninsular Malaysia was first recorded in the 1990s during scientific expeditions into the Belum-Temengor Forest Complex (BTFC), one of the Important Bird and Biodiversity Areas (IBA) in the country. Hundreds were documented moving *en masse* across the forest landscape annually between the months of August and October at dusk and dawn during their presumed non-breeding period. Between 2004 and 2007, the Malaysian Nature Society (MNS) monitored the monthly movements to/from communal roosting site(s) at a fixed location in Temengor Forest Reserve. From 2008 until 2012, a two-month daily monitoring effort was initiated under the MNS Hornbill Volunteer Programme (HVP) as a form of citizen science. The highest count in a single session was in September 2008 with over 3,200 individuals at dawn. Through the monitoring effort and cumulative data, it was shown that the number of Plain-pouched Hornbills seen fluctuates yearly, possibly corresponding with local phenological patterns in this vast forest complex. Spanning over 300,000 ha of tropical evergreen forests, BTFC is the largest forest complex in northern Peninsular Malaysia. The northern section of BTFC is also contiguous with another forest complex in southern Thailand i.e. the Bang Lang National Park and Hala-Bala Wildlife Sanctuary. Collectively, this trans-boundary forest complexes form an important stronghold for the long-term survival of the Plain-pouched Hornbill and other resident hornbill species. This paper summarizes the collated field information on Plain-pouched Hornbills to date in BTFC and discusses its conservation implications.

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Keywords: Plain-pouched Hornbill, *Aceros subruficollis,* Belum-Temengor Forest Complex, Important Bird & Biodiversity Area, MNS Hornbill Volunteer Programme, mass movement

INTRODUCTION

Asian hornbills across their ranges are increasingly threatened due to habitat loss and degradation and hunting/poaching. As many as 11 (34%) out of 32 Asian hornbill species are now listed as threatened under different IUCN Red List categories. Another 11 are listed as Near Threatened. The Plain-pouched Hornbill *Aceros subruficollis* has been categorized as Vulnerable with an estimated global population of between 1,500 and 7,000 mature individuals in Myanmar, Thailand and Peninsular Malaysia (BirdLife International 2013). Historically, the unbroken green belt of mixed deciduous, dry and humid evergreen forests stretching from southern Myanmar to northern Peninsular Malaysia would have provided this *Aceros* hornbill with its ecological and biological needs, especially during the post-breeding period where they form large flocks and roam, possibly, in search of food. Their seasonal movements *en masse* must truly rank as one of the spectacles of nature in Asia (Davison 1995b). Continued decimation and degradation of large forest tracts, if unabated, would undoubtedly disrupt this natural process. To date, large Plain-pouched Hornbill populations are confined to remaining forest in western Thailand/Myanmar and southern Thailand/northern Peninsular Malaysia. Following the recommendations of BirdLife International, the Malaysian Nature Society (MNS) has been monitoring Plain-pouched Hornbills in the Belum-Temengor Forest Complex (BTFC) since 2004 under the MNS Hornbill Conservation Project. Results of monitoring in 2008 were published by Kaur et al. (2011). This paper collates and summarizes the field data collected from 2004 to 2012, and discusses its conservation implications.

Belum-Temengor Forest Complex

Located in the northern Peninsular Malaysian State of Perak, the Belum-Temengor Forest Complex encompasses several forest blocks spanning over 320,000 ha that are administered by the Perak State Park Corporation and Perak State Forestry Department. About one-third of this forest complex has been gazetted as a protected area i.e. Royal Belum State Park (117,500 ha) while the remaining parts are classified as Forest Reserves (Banding, Temengor, Gerik and Amanjaya). Under Peninsular Malaysian's forestry laws, Forest Reserves can either be functionally categorised as production (i.e. timber) or protection forests (e.g. High Conservation Value Forest, water catchment, Virgin Jungle Reserve (VJR), education, wildlife, areas 1000 m asl and above, etc). The Forest Reserves within BTFC have both functions but logging (under

the Sustainable Forest Management system) is the primary function A dendritic Temengor Lake forms the 'centrepiece' of BTFC as a result of the damming of the Perak River in the 1970s. A major highway *i.e.* the East-West Highway was constructed about the same time and now bisects BTFC. The northern section of BTFC is contiguous with the protected areas of Bang Lang National Park and Hala-Bala Wildlife Sanctuary in southern Thailand.

The terrain of BTFC is mostly hilly (Davison 1995a). Its lowest lying points in the south-west are at about 130 m asl and it reaches about 1,000 – 1,400 m asl along the watershed forming the Perak-Kelantan State border in the east and parts of the Titiwangsa Range. To the north along the Perak-Thailand border, the terrain reaches the high points of several peaks i.e. Ulu Titi Basah (1,533 m asl) and Ulu Merah (1,450 m asl). The forest complex is dominated mainly by *Shorea* spp. in hill dipterocarp forest, with sub montane forest on the upper slopes (Figure 1).

Several scientific expeditions into BTFC organized by MNS, local universities and/or government agencies have shown that the forest complex supports exceptional biodiversity (Davison et al. 1995; Latiff and Yap 2000; Latiff 2011). It is recognized internationally as one of Malaysia's Important Bird & Biodiversity Area (IBA) (Yeap et al. 2007).

Discovery of the Plain-pouched Hornbills in Peninsular Malaysia

The *Aceros* hornbill movements in Peninsular Malaysia were first discovered in August 1992 when about 300 individuals were seen making dawn and dusk flights to and from Tasik (=lake) Kenering (Ho and Sutari 1993). Ho and his co-workers returned a few months later and conducted a four-day survey of the area. During the survey, they encountered the phenomenon daily and counted a maximum of 764 *Aceros* in flight. The physical markings and calls of these *Aceros* hornbills bore a resemblance to the Plain-pouched Hornbill *Aceros subruficollis*, which had not been known from Malaysia at that time.

In the following year, MNS led the first Heritage and Scientific Expedition into Belum-Temengor, with a base camp at Sungai (= river) Halong (Temengor Forest Reserve). During this period, the mass movement of *Aceros* hornbills was again documented. Observers counted 2,421 individuals on 24 November 1993 flying in a north-south direction over the base camp area in the evening. On 25 November, 2,365 individuals were recorded. Tunku Mohd. Nazim Yaacob (1994) reported an evening wave of 1,277 "Wreathed Hornbills" *Aceros undulatus* in August 1994.

MNS led a second Belum-Temengor expedition in 1998 and established base camp at Sungai Tan-Hain (then Belum Forest Reserve), when Lim and Tan (2000) encountered unidentified hornbills (most likely *Aceros* spp.) making evening flights in "considerable numbers from camp

everyday from 17 to 20 May". However, the final count was only 233 individuals. Ho and Sutari (2000a, 2000b) consistently recorded over 1,000 Plain-pouched Hornbills in September 1998 during their five-day survey at Pos Chiong (Temengor Forest Reserve). The maximum count was 2,067 individuals.

In 1999, Ho and his co-workers officially submitted their previous findings to the MNS-Bird Conservation Council for scrutiny. Within the same year, the 'mystery hornbill' was identified definitely as the Plain-pouched Hornbill *Aceros subruficollis* and accepted as Malaysia's tenth hornbill species (Records Committee, MNS-BCC 2000) (Figure 2). Earlier records of the Plain-pouched Hornbill in Malaysia were set aside due to the risks of confusion with other species prior to the clarification of taxonomy and status of Plain-pouched Hornbills by Rasmussen (2000).

MNS Hornbill Conservation Project

The MNS Hornbill Conservation Project (MNS HCP) was established in 2004, a year after the conclusion of the Royal Belum State Park Scientific Expedition in 2003 (25 July-1 August), with the dual aim of (1) conserving hornbills of BTFC in its natural habitats and (2) increasing awareness on the importance of hornbills and their habitats. The MNS HCP was also a clear indication of the Society's long-term presence and commitment towards the conservation of this forest complex. There are two components focusing on research and monitoring and Communications, Education and Public Awareness (CEPA) activities that form the operational pillars of the MNS HCP. Under the research and monitoring component, efforts are made to better understand the ecology of the Plain-pouched Hornbill, its utilization of BTFC and monitor this seasonal population.

MATERIALS AND METHODS

Throughout the nine years (2004-2012), the MNS HCP has employed three methods to improve the understanding of the movements of the Plain-pouched Hornbills within BTFC and monitor their numbers. These methods are explained below:

Monthly monitoring

Monitoring is conducted from a fixed location, either at Kampung (= village) Tebang/Pos Chiong or adjacent indigenous villages (05°25'58.96"N, 101°25'49.78"E) or occasionally from a nearby location at Pulau Kiroi (05°27'00.67"N, 101°24'58.53"E) in Temengor Forest Reserve. This location was chosen based on a reconnaissance trip in 2003 which seemed to indicate that a large proportion of the Plain-pouched Hornbills fly over or were in close proximity to this village

(Yeap and Noramly 2011). Thus, we postulated that Kampung Tebang is located along the hornbills' flight path between their roost site(s) and feeding area(s). From the top of a small hill in this village, the observer(s) have a 360o landscape-view of the immediate surroundings (as far as 1 km) hence it is possible to count the number of hornbills in flight. While every effort is made to count all visible hornbills during monitoring, some could avoid detection if they flew below the forest canopy, at the height of the treeline, behind hills or using alternate routes.

Typically, two counts were conducted per monitoring day *i.e.* after dawn (0700-0900 hours) and before dusk (1700-1930 hours). Population numbers and (where possible) sex, age, flight direction and behaviour were noted as well. Binoculars and telescopes were used to spot and count the hornbill flocks and individuals.

While every effort was made to monitor the hornbills consistently on a monthly basis at Kampung Tebang every year, the limitation of resources (manpower and funds) could not be avoided in some years. From 2004-2007, total monitoring days per year ranged from 13 to 44 days spread out between eight to 11 months. Effort was least in 2005 where only four months (13 days) were covered. Between 2008 and 2012, the MNS Hornbill Volunteer Programme was introduced whereby participants assisted experienced MNS counter(s) to monitor the hornbills for two months *i.e.* August-September annually. Through this citizen-science effort, intensive daily counts were possible during this period. The total number of monitoring days in these two months ranged between 60 and 79 days per year during the five-year period.

Simultaneous counts

In order to identify major and minor flight paths, small groups of seasoned MNS observers, who have field experience in identifying Plain-pouched Hornbills, were placed at several locations within the Royal Belum State Park and Temengor Forest Reserve suspected to be part of the hornbills' flight path. Information gathered followed the monitoring protocol. This exercise was conducted in 2010 and 2011.

Roost searches

Ground surveys were conducted during the 'Plain-pouched Hornbill months' to locate their roost site(s) believed to be situated in Temengor Forest Reserve. Once the flight direction of the hornbills to their suspected roost site(s) had been determined, survey teams would follow and search for visual/physical clues of roost(s) e.g. droppings, feathers etc. Surveys have been conducted twice i.e. in 2004 and 2010.

RESULTS AND DISCUSSION

What do we know from the monitoring results?

Over the course of nine years (2004-2012), MNS was able to maintain monitoring presence at Kampung Tebang/Pos Chiong for 71 months (65% of the total number of months). A total of 461 count days were spent monitoring the hornbills involving 712 count sessions i.e. 384 dawn counts and 328 dusk counts. The difference between the total number of dawn and dusk counts was primarily caused by the cancellation of counts due to adverse weather conditions e.g. heavy rains that were more frequent in the afternoons, and other unforeseen circumstances. The counts totalled 1588 hours.

Taking into account only the maximum monthly counts, Figure 3 shows an interesting 'high-low' alternate pattern over the period of nine years. The highest number of individual hornbills counted (i.e. peak count) in a single session was 3,261 in 2008 followed by 2,734 in 2012, both in September. The 'lowest' peak count was 85 individuals in August 2009.

The arrival and build-up of the hornbills starts as early as the end of May leading to a peak around August or September before a gradual decline in numbers (Figures 4A-E). More hornbills were counted in the dawn counts compared to the dusk counts. This led to our assumption that some of the hornbills could have used other 'minor' flight path(s) that were not detected by our monitoring and survey teams.

At Kampung Tebang, observers started to detect hornbills as early as 0630 hours, although it was still dark. The peak Plain-pouched Hornbill movements, however, fell within 0700-0729 hours (n = 311), which coincided with first light from the sunrise in this landscape. Within this period, the highest number of hornbills counted in a single flyby was 3,152 individuals followed by the next hour i.e. 0730-0759 hours (n = 200) (Table 1). At dusk, the large majority of hornbills were detected within the 1800-1859 hours period.

Which flight path(s) are hornbills using?

Simultaneous surveys were attempted once in 2009, 2010 and 2011 respectively. While monitoring efforts were on-going in Kampung Tebang, smaller count teams of experienced birdwatchers were positioned at several locations or river valleys e.g. Sungai Halong, Sungai Tiang etc. suspected to be part of the hornbills flight path(s). The counts from these locations showed that some hornbills do use river valleys as navigational landmarks within their flight path to a certain extent.

Where are they roosting?

The annual presence of the hornbills in BTFC, although numbers seem to fluctuate yearly, ignites a pertinent question as to the exact location(s)

of their roost. Our monitoring data suggest that the hornbills move between their feeding and roost site(s) in Temengor every day during the months of July and October. Their flight direction, generally from south/southwest to north/northeast in the morning, and the reverse in the evening, points to possible locations of roost site(s) south/southwest beyond Kampung Tebang/Pos Chiong. Although ground surveys have been attempted twice, we have not been able to confirm the exact location(s) of the hornbills' roost site(s) to date. More attempts to locate these will be made in future. Prior to 2010, it was believed that the hornbills roosted in Temengor. However, simultaneous surveys in mid-August 2010 in Kampung Tebang (Temengor) and Sungai Tiang (Royal Belum State Park) suggested that as many as 1,600 Plain-pouched Hornbills could be roosting in the Sungai Temin area at the same time, at least for that year. These findings from the simultaneous surveys indicate perhaps that the hornbills could be roosting in several areas within this forest complex and are not confined to only a single area. However, it is not known if the hornbills return to the newly suspected roost area in Sungai Temin annually, hence more simultaneous monitoring efforts need to be invested to address this question.

Utilization of BTFC by Plain-pouched Hornbills

The cumulative field information strongly suggests that the Belum-Temengor Forest Complex is an important part of the hornbills population's life cycle (breeding/non-breeding) in northern Peninsular Malaysia/southern Thailand. The presence of Plain-pouched Hornbills in this forest complex could possibly be linked to its flowering/fruiting patterns although there has been no long-term monitoring of phenology. Previous expeditions have revealed interesting diversity of fruit trees found in this landscape (Latiff et al. 1995; Salma et al. 2000). Based on this information, a 'typical' yearly cycle for Plain-pouched Hornbills in BTFC could perhaps be described as follows:

From January to May, mature hornbills would initiate breeding in southern Thailand and/or BTFC (although the nest trees have yet to be found here) and would only leave the nest tree upon completion of their breeding cycle. At the same time, small numbers of immature or unpaired hornbills would linger in the BTFC in search of fruiting trees. As the breeding season comes to an end in May, the number of hornbills begins to build up in the landscape. New family units (pairs and new-fledged young) augment the existing non-breeding population in search of fruiting trees. This build-up occurs from end of May onwards and peaks in August or September, which also coincides with the second flowering season in Upper Perak (Corner 1988). The large seasonal hornbill population starts to dissipate in October towards the onset of another new breeding season.

The Hornbill Triangle (HoT)

The contiguity of the BTFC and Bang Lang National Park/Hala-Bala Wildlife Sanctuary (BLNP/HBWS) provides a vast forest area for hornbills to roam, feed and breed thus supporting its life cycle and processes. Another piece of the puzzle emerged in July 2004 when hornbills were also reported from another forest complex located north-west of BTFC in the adjacent state of Kedah: the Greater Ulu Muda Forest Complex (GUMFC) (Yeap et al. 2005). The GUMFC comprises of the Ulu Muda, Pedu, Chebar Besar and Padang Terap Forest Reserves and includes the proposed Ulu Muda Tambahan, Bukit Keramat and Bukit Saiong Forest Reserves with a total area of about 160,000 ha of lowland and hill dipterocarp forests. Monitoring of hornbills in GUMFC is patchy due to lack of resources. Despite this shortcoming, data from 2004, 2008, 2010 and 2011 showed that the hornbills do utilize this forest complex as well. The highest count was about 1,200 individuals (2004) but subsequent counts were less than half of this figure. The 'combination' of the three large forest complexes forms a "Hornbill Triangle" (HoT) (Figure 5).

The discovery of Plain-pouched Hornbills in GUMFC provokes several questions; where do they originate from, what is attracting them to GUMFC, are they breeding there, are they part of the larger BTFC flock or separate, do they fly to BTFC from GUMFC, etc. *Aceros* hornbills are known to travel long distances for food resources. Given that much is still unknown about their life cycle and conservation needs, the HoT area most likely offers the best chance of survival for the southern population of Plain-pouched Hornbills.

CONCLUSIONS

Davison (1995b) once remarked that "*the totals of more than 2000 hornbills at Temengor seem to be unprecedented anywhere in the world for any hornbill species, but there are now sufficient reports to be sure that substantial numbers are of regular occurrence there*". The seasonal migration of Plain-pouched Hornbills must rank as one of the most spectacular natural wonders in Asia. The Hornbill Triangle offers the best hope for the future survival of the southernmost population of Plain-pouched Hornbills. Efforts need to be continually invested in improving our understanding of the ecology and biology of resident hornbills, monitoring hornbill populations including the hornbills, engaging local indigenous communities and securing better habitat conservation.

ACKNOWLEDGEMENTS

We would like to thank the Forestry Department Peninsular Malaysia, Department of Wildlife and National Parks (Peninsular Malaysia), Perak State Parks Corporation, Zoo Negara and Hymeir Kamarudin (Earth Lodge Sdn. Bhd.) for their support and assistance in the MNS HCP. The MNS HCP is also indebted to our three Orang Asli field assistants i.e. Roslan Carang, Azam Carang and Marisan Pandak (from Kg Chuweh), the Tok Batin and villagers of Kampung Tebang, all the MNS HCP and HVP volunteers (2008-2009) and MNS Secretariat colleagues. We would also like to thank our previous donors who helped kick-start the MNS HCP and more recently Sime Darby Plantation Sdn. Bhd. and Sime Darby Foundation, which provided much needed long-term support. Schidmt Marketing (Malaysia) Sdn. Bhd. generously loaned high-quality optics.

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Table 1. Breakdown of Plain-pouched Hornbill arrival patterns at (a) dawn and (b) dusk according to half-hour blocks at Kampung Tebang, Temengor Forest Reserve (2004-2012).

(a) Dawn

Time (hours)	0600-0629	0630-0659	0700-0729	0730-0759	0800-0829	0830-0859	>0900
Number of Individuals	0	1-1348	1-1,3152	1-1,641	1-466	1-173	2-115
No. of Occasions (n)	0	144	311	200	104	132	4

(b) Dusk

Time (hours)	1600-1629	1630-1659	1700-1729	1730-1759	1800-1829	1830-1859	1900-1929	1930-1959
Number of Individuals	2-30	1-314	2-1, 130	1-839	1-1, 595	1-1, 728	1-968	2-70
No. of Occasions (n)	11	31	79	137	186	169	78	7

Figure 1. A landscape view of the Belum-Temengor Forest Complex. (Photo credit: KH Khoo/MNS)

Figure 2. A group of at least 70 Plain-pouched Hornbills resting on an emergent in Belum-Temengor Forest Complex. (Photo credit: Lim Kim Chye/MNS)

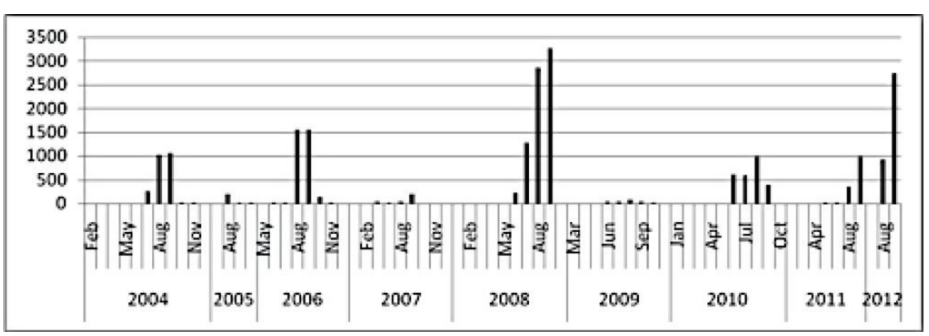
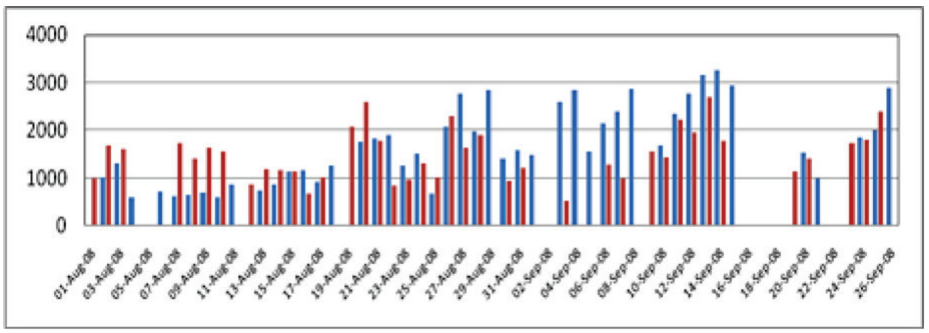


Figure 3. Monthly maximum counts of the Plain-pouched Hornbills at Kampung Tebang, Temengor Forest Reserve (2004-2012).

(4A)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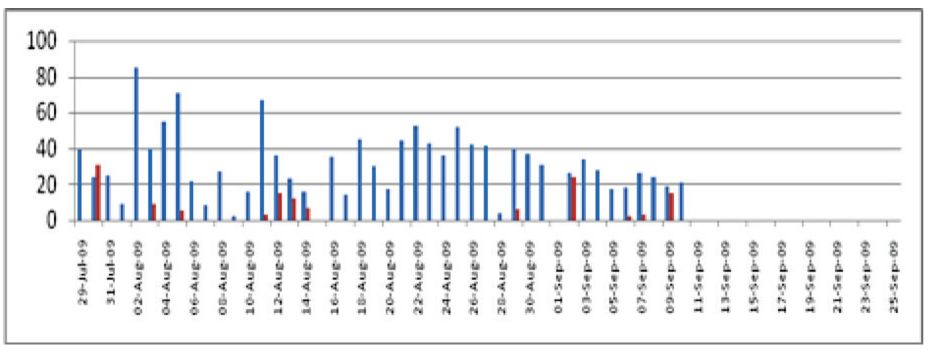
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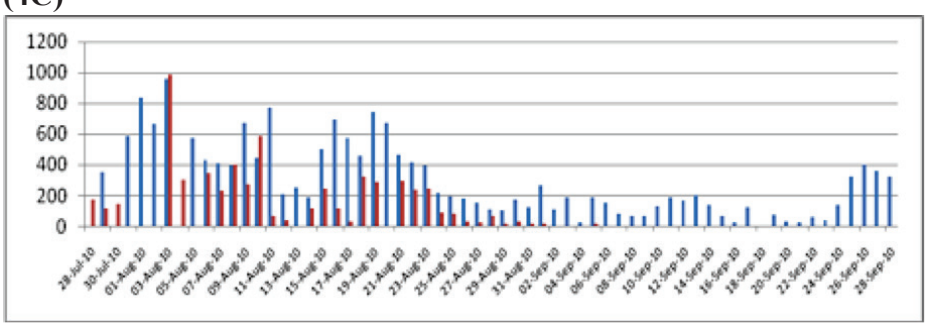
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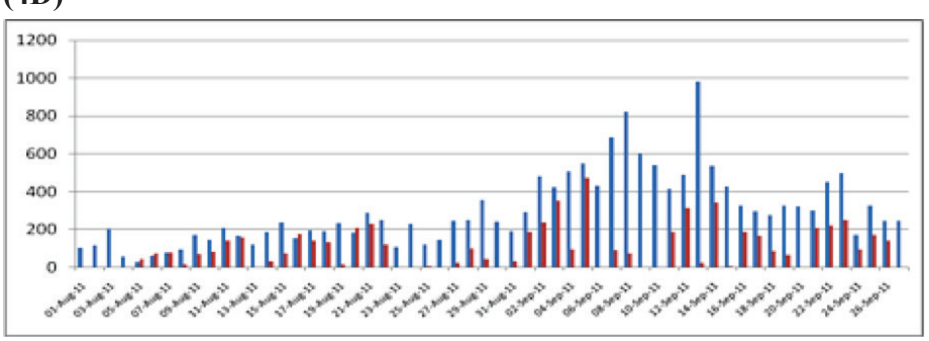
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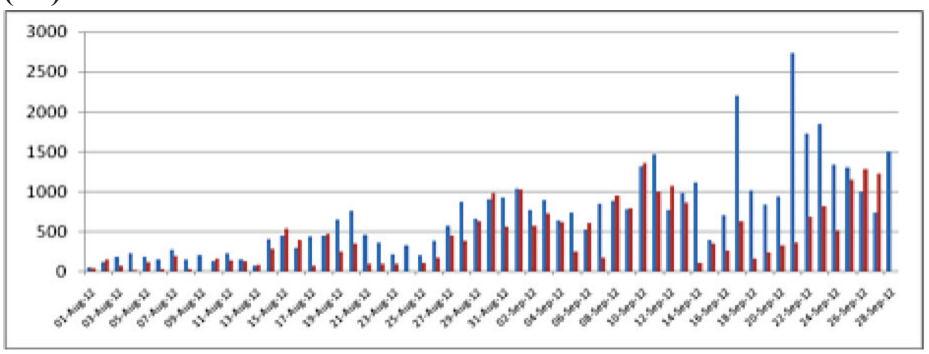

Figure 4. Daily counts of the Plain-pouched Hornbills at Kampung Tebang during the MNS Hornbill Volunteer Programme in August and September (A: 2008 – E: 2012).
[Note: BLUE = dawn count / RED = dusk count]

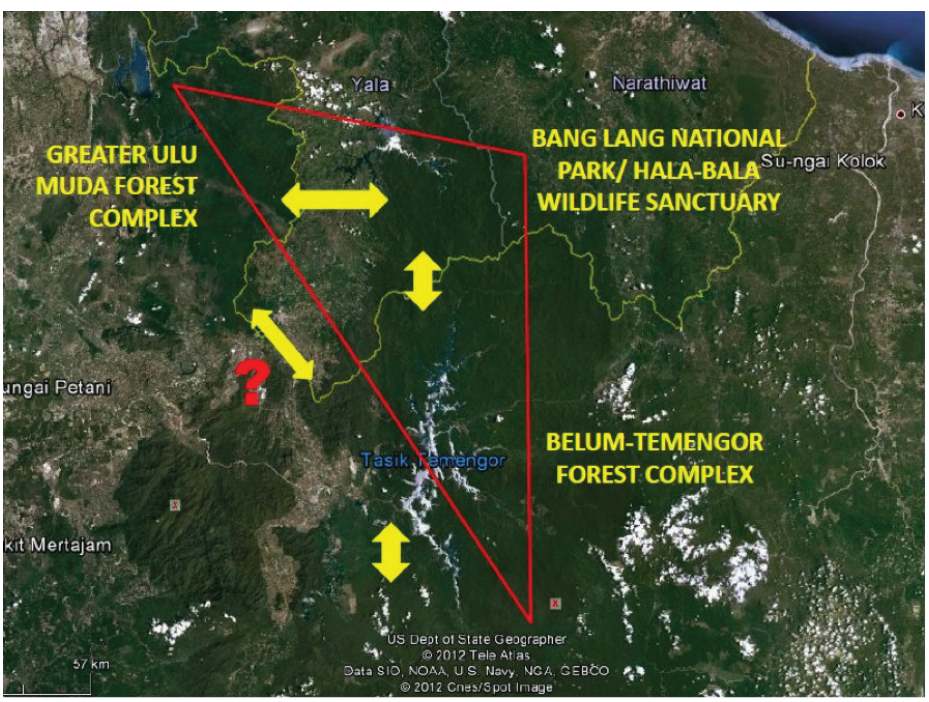

Figure 5. The Hornbill Triangle (HoT) in northern Peninsular Malaysia and southern Thailand. *[Note: Image generated from Google Earth.]*

Distribution and status of Rufous-necked Hornbill *Aceros nipalensis* in Myanmar

THET ZAW NAING[1*]

Abstract: The Rufous-necked Hornbill *Aceros nipalensis* was once widely distributed in Myanmar, and was formerly recorded in the northern, central, southeastern and eastern regions of the country as well in northern Taninthayi (= Tenasserim). Recently, however, it has been recorded at only a few sites, and is currently listed as Vulnerable (BirdLife International 2001). Surveys from 2000 to 2012 recorded this species in northern, southern, and western Myanmar. In North Myanmar (Kachin State and Sagaing Division), this species has been recorded at 12 sites; most individuals were located in the Hponkanrazi (n=64) and Hukaung Valley (n=76) Wildlife Sanctuaries (WS), with at least 64 and 76 individuals recorded, respectively. In the west (Chin Hills) and south (Magwe Division), this species has been found only in three areas, one area in West and two areas in South, with a total of four and 10 birds recorded at West and South respectively. The results of recent surveys have found only a few individuals in most of the surveyed areas but indicate that the Hponkanrazi and Hukaung Valley WS's support the highest number of individuals. Widespread habitat loss, degradation and disturbance represent a significant threat to this species. Hunting is likewise a major threat. This paper is not a recent population estimate for the species. There is an immediate need for additional surveys to clarify their recent population status in Myanmar. Some areas, such as eastern Myanmar (Shan and Kayah States), remain to be surveyed for Rufous-necked Hornbill. Current gaps in our knowledge include present status and long-term population trends, and we recommend revisiting all sites where this species occurred historically, to address this.

Keywords: Rufous-necked Hornbill, *Aceros nipalensis*, Myanmar, Hponkanrazi Wildlife Sanctuary, Hukaung Valley Wildlife Sanctuary

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INTRODUCTION

The Republic of the Union of Myanmar is the largest country in mainland Southeast Asia with a total land area of 676,577 km². It is located between latitude 9˚28' - 28˚29' N and longitude 92˚10' - 101˚10' E. The country is bound by the People's Republic of China in the north and northeast, Lao P.D.R. and Thailand in the east, and Bangladesh and India in the west. Myanmar is approximately 2,100 km (length) x 925 km (width) and has seven divisions and states respectively, which are the Ayeyarwaddy, Bago, Magwe, Mandalay, Sagaing, Tanintharyi and Yangon Divisions, and Chin, Kachin, Kayah, Kayin, Mon, Rakhine and Shan States (Figure 1). The country is divided into seven geographic regions, which are North, East, South, West, Southwest, Central and Tanintharyi (formerly known as Tenasserim) (Figure 2).

The physical geography of Myanmar is structurally complex and diverse, with steep mountain ranges, upland plateaus and hill valleys in the eastern, northern and northwestern regions, while the undulating central dry zone is surrounded by the western coastal range. The southern part of the country is characterized by a lowland deltaic region and a narrow coastal strip adjoins peninsular Thailand. From north to south, four major rivers occur, namely the Ayeyarwaddy (formerly known as the Irrawady), Chindwin, Sittaung and Thanlwin (formerly known as the Salween), and these are associated with the complex terrain formed by large drainage systems and their wider tributary networks. As part of the eastern Himalayan mountain range, Mount Hkakaborazi, located in the far north of the country with an altitude of 5,881 m asl, is the highest mountain in southeast Asia. The climate of Myanmar is classified as tropical monsoonal, with three distinctive seasons, a hot season from March to May, rainy season from June to October, and a cold season from November to February. Rainfall is highly variable ranging from 500 mm in the Dry Zone to over 6,000 mm in Tanintharyi Division and northern Rakhine State. Due to the interaction of geography, topography and climate, Myanmar contains a great variety of habitats and ecosystems that support a rich biodiversity. With about half (48%) of the mainland still covered by forests (FAO 2010), Myanmar ranks sixth out of the 11 southeast Asian countries in terms of percentage of land area covered by forests (FAO 2009).

Due to the geography of Myanmar, habitat types are very diverse. As a result, Myanmar also supports a great variety of avifauna, approximately 1,100 species. Among the several hundred species of resident forest birds, there are 10 species of hornbills. These include Northern Brown *Ptilolaemus austeni*, Southern Brown *Ptilolaemus tickelli*, Bushy-crested *Anorrhinus galeritus*, Oriental Pied *Anthracoceros albirostris*, Great Buceros *bicornis*, Helmeted *Rhinoplax vigil*, White-crowned *Berenicornis comatus*, Rufous-necked *Aceros nipalensis*, Plain-

pouched *A. subruficollis* and Wreathed Hornbills *A. undulatus*. This paper is focuses on only the Rufous-necked Hornbill, which is listed as 'Vulnerable' by BirdLife International (2001). This species originally occurred in mountainous regions between eastern Nepal and Vietnam. Although now absent or very rare throughout its distribution, the Rufous-necked Hornbill still occurs in southern China, northeastern India, Myanmar, western Thailand, Laos and Vietnam. There are no confirmed recent records from Bangladesh and the species may be locally extinct (BirdLife International 2001).

Historical status and distribution of Rufous-necked Hornbills in Myanmar

The Rufous-necked Hornbill was once widely distributed in Myanmar. It was recorded from North, Central, East and South Myanmar and north Tenasserim (=Taninthayi) (Tables 1 and 2, Figure 3).

RESULTS

Myanmar has been very poorly covered by ornithological surveys in recent years. However, a limited number of recent ornithological expeditions conducted from 2000 to 2012 found the Rufous-necked Hornbill in North, South and West Myanmar (Figure 3, Tables 1 and 2). In North Myanmar (Kachin State and Sagaing Division), this species has been recorded at 12 sites; in Kachin State at Hkakarborazi National Park, Hponkanrazi Wildlife Sanctuary, Putao, Machanbaw, Naungmung, Kaunglanphu, Sumprabum, Myitkyina, Chibwe and Tsawlaw areas, Indawgyi Wetland Wildlife Sanctuary and Hukaung Valley Wildlife Sanctuary (Figure 4); Hukaung Valley WS is situated between Kachin State and Sagaing Division.

These records show that at least 217 individuals of Rufous-necked Hornbill have been encountered recently in North Myanmar.

In West Myanmar (Chin State and southern part of Naga Land in Sagaing Division), at least 15 birds at Tishi Village in 2009 (Saw 2009) and one bird at Tikun Village in 2012 (Thet et al. 2012) were recorded near Mount Saramati on the southern part of Naga Land in Sagaing Division. In Chin State (Chin Hills), a pair was recorded at Natmataung National Park in 2000 (Thet 2001) and a pair was found near Twishi Village at Matupi area in 2012 (Thet et al. 2012) (Figure 5). Above these records, about 20 individuals of Rufous-necked hornbill were listed in West Myanmar. Formerly this species was not found there.

In South Myanmar, especially in the north-west of South Myanmar, a total of 10 birds were recorded at two sites (Figure 6). Four birds on

Natyekan Mountain Range and six birds near Goatsiyo Village were recorded respectively at Ngape area of Magwe Divison in 2009 (Ngwe et al. 2009). This is the first record of this species from there. Robson (2008) lists the species only from the east of South Myanmar. Of these recent surveys from 2000 to 2012, this species has been recorded at three geographic regions of Myanmar; most of these were located in the North especially at Hponkanrazi and Hukaung Valley Wildlife Sanctuaries, with at least 64 and 76 individuals recorded, respectively.

CONCLUSIONS

Habitat loss and over-hunting are the two major threats facing Rufous-necked and other Hornbill species in Myanmar. Though all species of hornbills in Myanmar are protected under the Protection of Wildlife and Conservation of Natural Area Law (Forest Department 1994), large numbers of hornbills are hunted for food, and their casques and tail-feathers (of Great and Rufous-necked Hornbills) are used by the Naga tribe for ceremonial and tribal headgear; moreover, some hornbills are kept as pets (author's personal observations).

The results of the surveys indicated that Hponkanrazi and Hukaung Valley Wildlife Sanctuaries in North and Mount Saramati area in West Myanmar are of high national significance for the conservation of the birds. Potentially it is also of high global significance, and a major global site for Rufous-necked Hornbills. The recent status of Myanmar's hornbills remains poorly known. Some areas have not yet been surveyed for Rufous-necked Hornbill, especially in the East (Shan and Kayah States) and Tenasserim (Kayin and Mon States) where security concerns hamper fieldwork, and numerous information gaps exist for this species. More data is urgently needed to properly understand the status and conservation management needs of all hornbills in Myanmar. There is an immediate need for additional surveys to clarify their conservation status and distribution at sites where these birds were historically recorded or the habitat appears suitable.

Hornbill habitats need to be protected from further destruction. All human disturbances should be stopped, and particular attention should be paid to protection of large, old-growth trees in the forests not encompassed within the protected area system. These trees are likely to provide hornbill breeding sites. Hunting and other direct threats to the bird should be eliminated and existing protective legislation enforced. There is an urgent need to heighten awareness amongst the general public, decision makers, planners and governmental administrators about the value of hornbills and the need to conserve their natural habitat.

ACKNOWLEDGEMENTS

U Than Myint (Country Programme Director) and the Wildlife Conservation Society–Myanmar Programme are thanked for organizing the expeditions and providing logistic support for survey trips. The Nature and Wildlife Conservation Division of the Ministry of Environmental Conservation and Forestry provided support during all surveys. In particular I wish to thank Director Win Naing Thaw and park wardens and staff of Hukaung Valley Wildlife Sanctuary, Hkakaborazi National Park, Hponkanrazi Wildlife Sanctuary, Natmataung National Park, Indawgyi Wetland Wildlife Sanctuary and Htamanti Wildlife Sanctuary. I am especially grateful to U Than Zaw and U Ngwe Lwin for sharing their survey reports and manuscripts. I also thank U Saw Htun, Steven, G. Platt, Robert J. Tizard and U Naing Lin for their advice and encouragement. I am also grateful for the enthusiasm and unflagging spirit of my survey colleagues.

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Table 1. Historical and recent status and distribution of Rufous-necked Hornbills in north Myanmar.

Location	Reference	Notes
Kachin State	Smythies (1949)	Recorded in Naungmung area in 1948.
	Than et al. (In prep.)	At least two birds on the Shinsarkhu Range in Naungmung area in 2007-2012.
		Two at Barbulone in Naungmung area in 2007-2012.
		Three on Namhti Range in Naungmung area in 2007-2012.
		Three at Sinlwindam Village in Naungmung area in 2007-2012.
		Two at Gawlae Village in Naungmung area in 2007-2012.
		Three on Maza Range in Naungmung area in 2007-2012.
		Two at Naungmung in 2007-2012.
		At least 17 birds at seven sites in Hkakarborazi National Park in 2007-2012.
	King et al. (2001)	Maximum of 38 individuals in Hponkanrazi Wildlife Sanctuary in 1998-1999.
	Thet et al. (2011)	At least 64 birds at 16 sites in Hponkanrazi Wildlife Sanctuary in 2011.
		Four birds were seen near Mali Yein village in Putao area in 2011.
	Ngwe et al. (2009)	Four birds at Ahtangar Village in Machanbaw area in 2009.
	Than et al. (In prep.)	Two birds on Naikha Range in Machanbaw area in 2012.
	BANCA (2009)	One near Wuni Village in Kaunglanphu area in 2009.
		Two at Kaunglanphu in 2009.
	Stanford and Ticehurst (1938–1939)	One bird near Hpungchanhka in Sumprabum area in 1933.
	Smythies (1949)	Recorded near Hpungchanhka in Sumprabum area.
	BANCA (2009)	Four birds at Hpa Wun Village in Sumprabum area in 2009.
	Ngwe et al. (2009)	Eight near Khagayanram Village in Sumprabum area in 2009.
	Stanford and Ticehurst (1938–1939)	A pair near Shagribum in Injangyang area in 1934.

Location	Reference	Notes
	Smythies (1949)	A flock of about eight and one at Laukkaung, N'Mai Hka drainage in Chipwe in 1948.
	Ngwe et al. (2009)	Three birds in Chibwe in 2009.
	BANCA (2009)	Two birds at Wusoke in Tsawlaw area in 2009.
	Ngwe et al. 2010	Seven near Mangi Village in Tsawlaw area in 2010.
		Two at Lakin River in Tsawlaw area in 2010.
	BANCA (2009)	Two at Bambane Village in Myikyina area in 2009.
		One bird at Myitsone in Myikyina area in 2009.
	Thet and Van dar Van (2005)	One bird in Indawgyi Wetland Wildlife Sanctuary in 2005.
	Thet et al. (In prep.)	At least 12 individuals in Hukaung Valley Wildlife Sanctuary in 2009-2011.
Sagaing Division	Thet et al. (In prep.)	At least 64 individuals in Hukaung Valley Wildlife Sanctuary in 2009-2011.

Table 2. Historical and recent status and distribution of Rufous-necked Hornbills in other regions of Myanmar.

Region	Location	Reference	Notes
West	Sagaing Division	Saw (2009)	At least 15 bird at Tishi village on Naga Land in Lashy area in 2009.
		Thet et al. (2012)	One bird at Tikun village on Naga Land in Lashy area in 2012.
	Chin State	Thet (2001)	A pair in Natmataung National Park in 2000.
		Thet et al. (2012)	A pair near Twishi village in Matupi area in 2012.
Central	Sagaing Division	Smith (1942)	Three birds at Katha district in 1932.
East	Shan State	Bingham and Thompson (1900)	Recorded at Loi-San-Pa in Nam Sam area in 1889-1900.
	Kayah State	Salvadori (1889)	One bird at Taho (Taho-au) in Demoso area in 1888.
South	Kayin State	Smith (1942); Smith et al. (1940–1944)	Recorded at north-west of Kolo valley, Nattaung in Hpapun area in 1940.
	Magwe Division	Ngwe et al. (2009)	Four birds on Natyekan Mountain Range in Ngape area in 2009.
			Six birds near Goatsiyo village in Ngape area in 2009.
Tenasserim	Kayin State	Tickell (1864); Hume and Davison (1878)	Recorded at Mulayit Wildlife Sanctuary in Kyain Seikkyi area.
	Mon State	Lowe (1933)	One male at Ta-ok plateau, in Kyaikmayaw area in 1924.

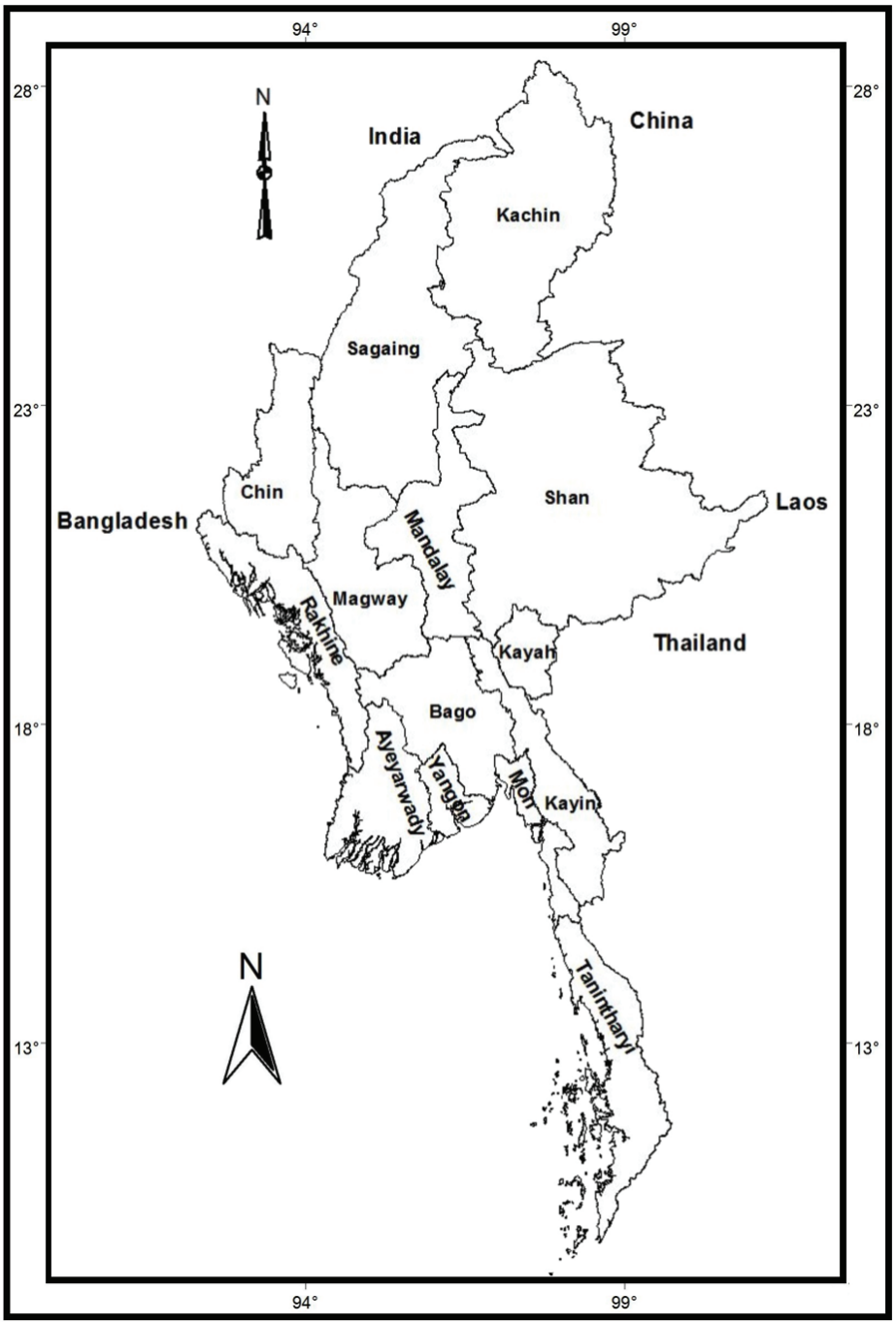

Figure 1. Geographical boundaries of states and divisions in Myanmar.

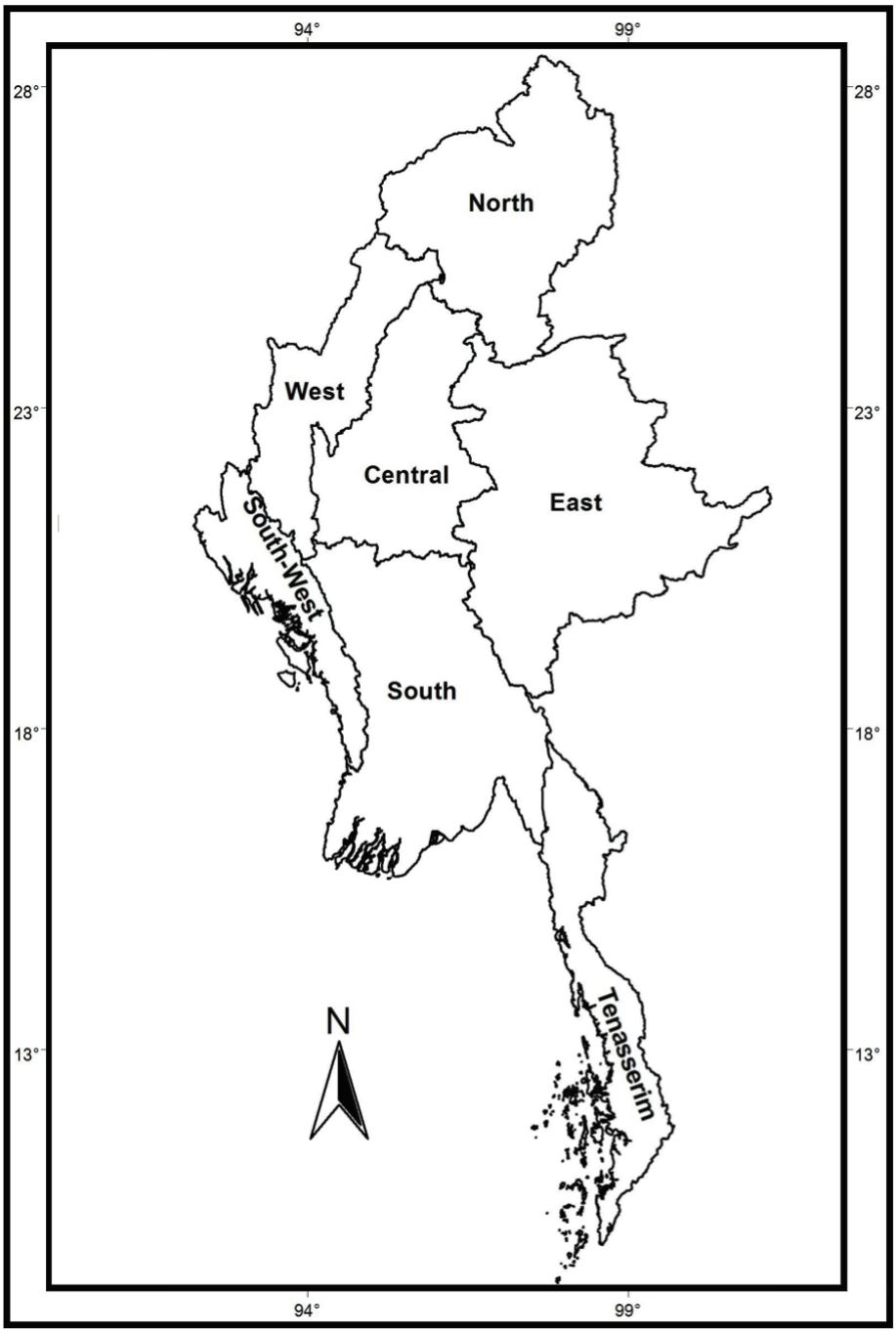

Figure 2. Geographic regions of Myanmar.

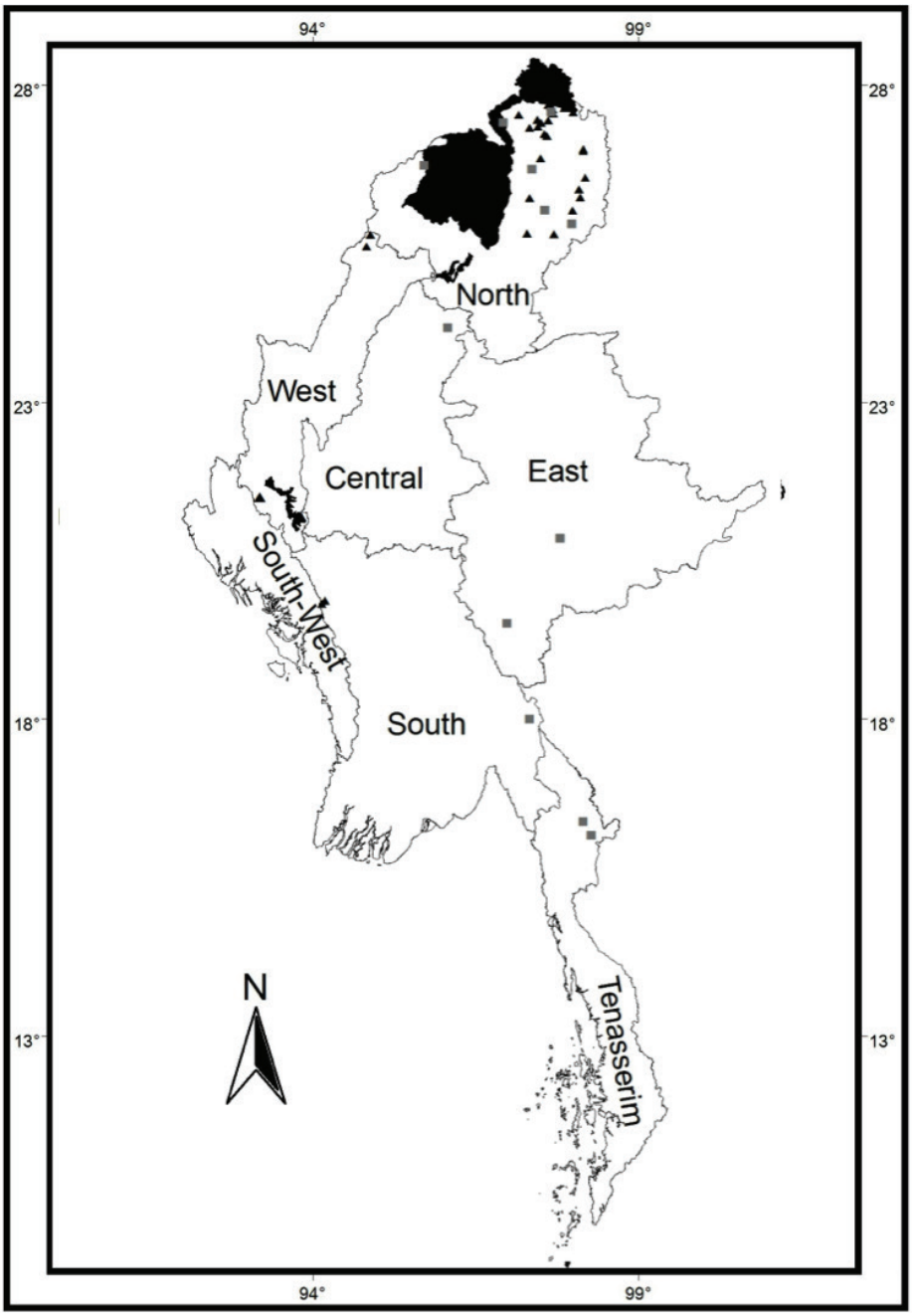

Figure 3. Historical and recent distribution of Rufous-necked Hornbills in Myanmar. (Lighter shaded denotes where historical sightings have occurred and darker shaded denotes where recent sightings have occurred.)

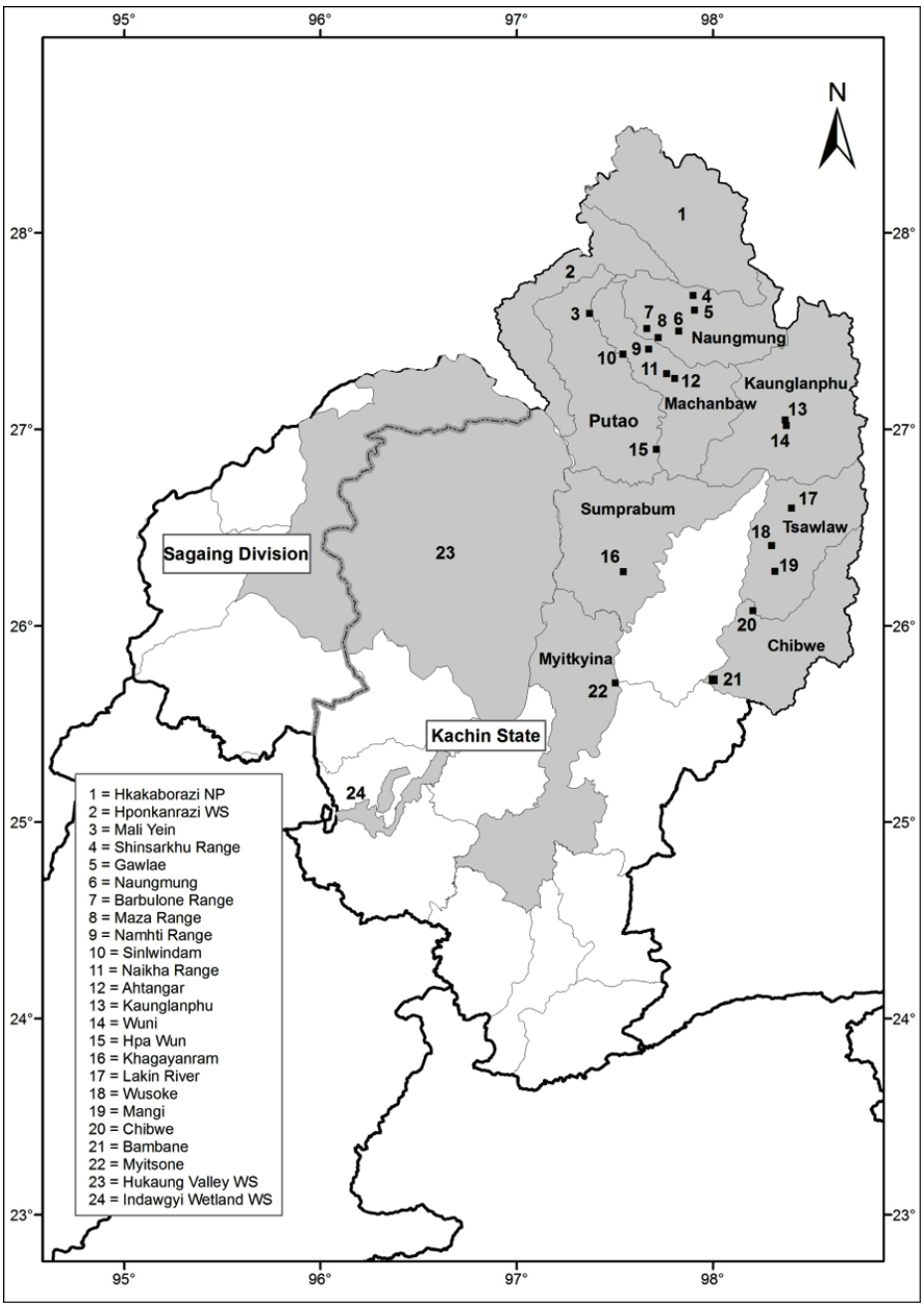

Figure 4. Recent recorded sites of Rufous-necked Hornbills in North Myanmar.
Note: Shaded areas denotes region where recent sightings have occurred. Locations indicated on map correspond to Table 1.

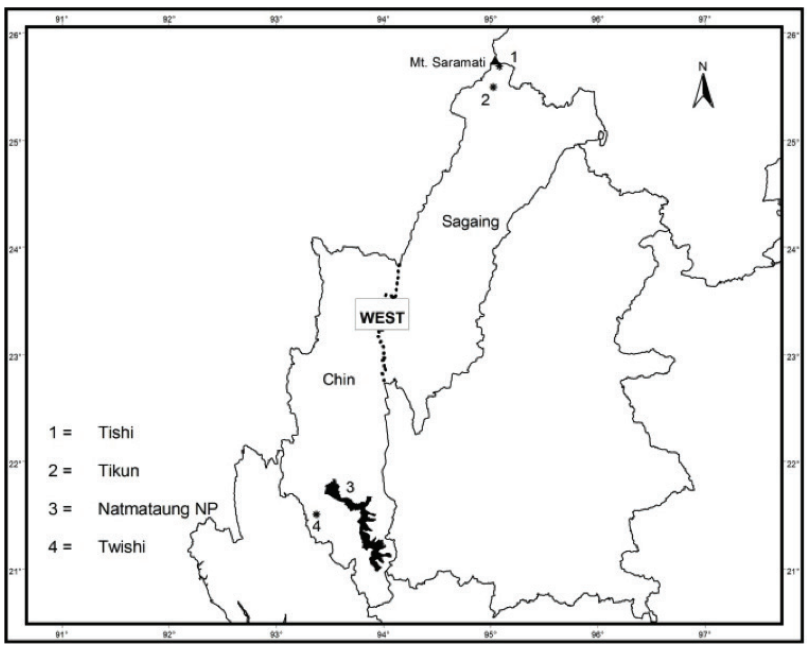

Figure 5. Recent distributions of Rufous-necked Hornbills in West Myanmar.

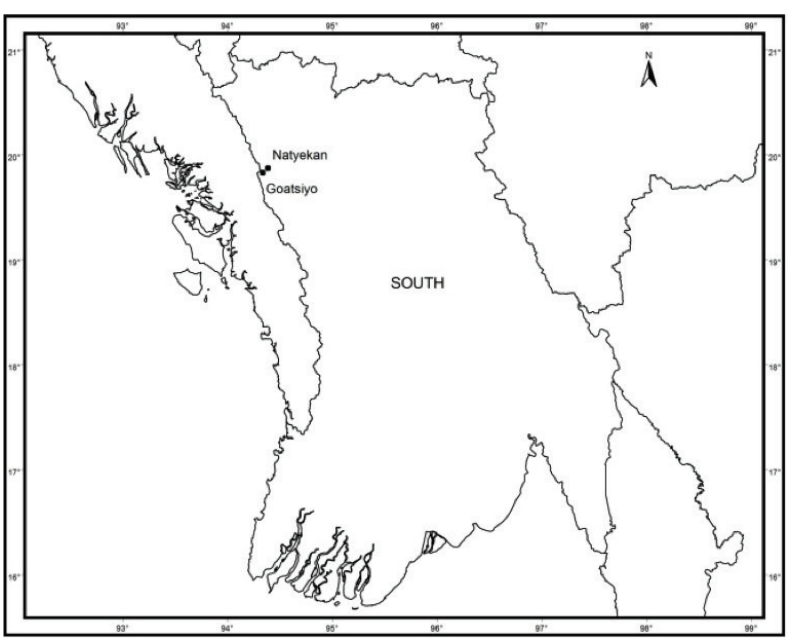

Figure 6. Recent distributions of Rufous-necked Hornbills in South Myanmar.

Ground-hornbills in American zoos: a case study of the challenges to *ex situ* population sustainability for conservation

ROGER G. SWEENEY[1*]

Abstract: Modern zoos pride themselves on their ability to maintain healthy captive populations as *ex situ* conservation resources with the potential to be used for future *in situ* conservation support and prevent harvest from wild populations under threat. This premise, however, is dependent on the ability of zoos to maintain sustainable populations, which are genetically and demographically viable. The Association of Zoos and Aquariums (AZA) in North America has established a management system of Species Survival Plans (SSPs) to ensure that conservation priority species are managed in a sustainable manner. However, for species where the population management is challenged by more complicated atypical factors such as social systems, reproductive biology and/or captive management costs, population sustainability can be difficult to achieve in reality. Both species of ground-hornbills are kept as captive populations in North American zoos and both are managed as SSP's. Achieving true population sustainability for these species has been challenging and the author conducted a case study assessment to better identify the challenges preventing the achievement of population sustainability, and to design strategies to overcome each of the challenges. Some of the challenges identified included the SSP not always being able to respond to institutional requests, recommended transfers not always taking place or being slow to be implemented, some genetically valuable birds not being available for transfer, low breeding success from some pairs identified as being high priority for breeding, and a concern over the breeding potential of some captive bred birds due to rearing method. Further analysis suggested that some of the root causes for these challenges included underestimation of the importance of social learning within an extended family cooperative breeding system for juvenile Southern Ground-Hornbills, the cage space and holding facilities of some zoos being a limiting factor to their success with ground-hornbills, the use of ground-hornbills in education programs (bird shows) preventing recommended pairings, and possible lack of staff experience with ground-hornbill behaviour limiting the breeding potential of some priority captive birds. Each of

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the challenges has been assessed and recommendations are presented to improve the success of the SSP captive populations to make them a more sustainable and credible conservation resource for the future.

Keywords: population sustainability, genetic diversity, demographic stability, husbandry, conservation, ground-hornbills.

INTRODUCTION

Ground-hornbills are large impressive birds, which are typically very active and highly visible as zoo exhibits. There are two species of ground-hornbill, the Abyssinian *Bucorvus abyssinicus*) and Southern Ground-Hornbills *B. leadbeateri*. Both live on African savannahs and lead a mainly terrestrial existence. Ground-hornbills differ from true hornbills by having an additional neck vertebra, elongated tarsi and a special tendon between pelvis and femur that allows them to walk and run with a long stride, enhanced by long legs and the ability to walk on the tip of the toes. Ground-hornbills also differ from most other hornbills in being predominantly faunivorous. They have black plumage over most of the body, except for white primary feathers that are hidden except when they take flight or extend their wings to jump. The tail is relatively short, nares are covered with a tuft of bristly feathers, eyelashes are well developed and flattened to form screens above the eyes. They breed in rock or tree cavities, not sealing the nest, showing no nest sanitation, the female being fed at the nest while incubating and brooding. Food is carried to the nest, often as a bundle of several items held in the bill that can include nest litter material as well as food. The female does not moult flight feathers simultaneously while breeding. The chick's skin turns from pink to black a few days after hatching, and the chick is often left alone in the nest well before fledging (Kemp 1995).

The Abyssinian Ground-Hornbill, also known as the Northern Ground-Hornbill, ranges through sub-Saharan African savannahs north of the equator. It is usually found living as adult pairs, sometimes with current offspring living with them. Breeding appears to be initiated by nest-site inspection, courtship feeding; and beak slapping between mates. Vocalization consists of a series of deep booming notes that may continue for lengthy periods (Kemp 1995).

The Southern Ground-Hornbill was formerly widespread across African savannahs south of the equator. Southern Ground-Hornbills live in extended family cooperative breeding units, where juvenile males can stay with the parents living as a family social group and acting as 'nest helpers' for up to 20 years. Female juveniles by comparison usually stay with the family for only one to three years after fledging. All members of the family unit coordinate their activities and remain closely together throughout the day. Social organization is maintained by allopreening

and complex interactions involving giving and withholding food. Vocalization consists of a main loud call that is a deep, resonant, four-note booking, accompanied by three body contractions the last of which produces a double note. This call is given by all family group members throughout the day, but most frequently at dawn and dusk. Adult male and female will often "duet", with the male calling at a lower pitch than the female, but any family member may call at either pitch (Kemp 1995).

Ground-hornbills were first seen on display in North American zoos in 1922 when the Philadelphia Zoo acquired wild caught specimens of the Southern Ground-Hornbill. Ground-hornbills started to appear more regularly in North American zoos over the ensuing 50 years with the first captive breeding successes being recorded during the 1970s. The first records of captive breeding in North American zoos began in the 1970s when the San Diego Wild Animal Park (now called San Diego Zoo Safari Park) achieved captive breeding of the Abyssinian Ground-Hornbill in 1973 and a few years later the Jacksonville Zoo achieved captive breeding of the Southern Ground-Hornbill in 1979.

Both species of ground-hornbill are currently managed by the AZA as Species Survival Plans (SSP), with the author acting in the role of species coordinator for both species since 2008. A North American regional studbook has been published annually since 2008 and a population analysis, breeding and transfer plan document has been produced for both ground-hornbill species (Sweeney and Lynch 2011, 2012).

Key tasks for the role of an SSP coordinator include maintaining a genetic studbook for the population and undertaking periodic population analysis, leading to transfer and breeding recommendations with a view to manage the captive population as sustainable as possible while meeting four main objectives: (1) maintain demographic stability of the population, (2) maintain genetic diversity in the population, (3) maintain population at the recommended target population size, and (4) meet institutional needs within a cooperative management system.

Populations are generally assessed against risk definition parameters including:

- Is current gene diversity high (the proportional gene diversity, as a proportion of the source population)?
- Is the projected gene diversity over 100 years viable?
- Are there enough breeding age birds in the population?
- Are a sufficient number of zoos keeping the species?
- Is current husbandry and breeding management successful?
- Is disease in the captive population a factor?
- Is behavioural quality of captive bred birds a concern?
- Is the history of the animals in the captive population known?

Background

Soon after taking over the task of coordinating ground-hornbill SSPs in 2008, the following programme performance concerns with these populations became apparent to the author.

The SSP had not always been able to meet institutional requests from zoos looking for birds to pair up single birds or establish new exhibits; often there can be a time delay in managed populations between institutional requests for birds and being able to match, but this population seemed to have some requests that were not being met. Some of the recommended transfers that were made were very slow to be completed or were not happening at all. This was partially because some genetically valuable birds were not available for pairing, often because they were trained to perform in education demonstrations with zoos not being prepared to move the bird because of their education/performance value.

In addition to the problems with transfers to form new pairings, there was also relatively low success with breeding from priority potential founders. The population data for the Southern Ground-Hornbills showed only 21% of wild caught potential founders in zoos had successfully bred and raised offspring, while for Abyssinian Ground-Hornbills 31% of wild caught potential founders had raised chicks.

Finally there was growing concern about the breeding potential of first generation Southern Ground-Hornbills, with an obvious lack of breeding behaviour from many mature birds compared to the Abyssinian Ground-Hornbill. Both ground-hornbill species had demonstrated captive breeding in North America zoos since the 1970s, with both species now having significant numbers of mature first generation birds. For the Abyssinian Ground-Hornbill, 54% (37 of 68) of the first generation birds had become reproductively successful while for the Southern Ground-Hornbill that number was just 3% (2 of 61), with both examples being first generation males that had been paired with wild caught males and which had been through a long series of breeding attempts before becoming successful. While captive offspring of the Abyssinian Ground-Hornbill, with a basic monogamous pair bond and short period until chick dispersal, appeared to respond well in zoo population management parameters, there was significant concern that captive management for the Southern Ground-Hornbill, with a more complicated extended family cooperative breeding system, seemed to produce first generation birds that were showing a significant lack of breeding potential.

METHODS

From summer 2009 through early 2010, a number of steps were taken to investigate the status and potential problems with the captive populations

of both ground-hornbill species. In preparation for upcoming population analysis for both of the ground-hornbill populations, a needs and wants survey was conducted of all North American zoos. An extensive literature search was conducted. A detailed husbandry was prepared covering three main knowledge areas: (1) cage space and physical environment requirements, (2) husbandry parameters, and (3) breeding information. Two months after circulation of the survey, a reply rate of over 80% was achieved and the results analysed (Table 1, Figure 1). In addition to the quantitative written surveys the author also conducted a series of qualitative interviews with zoo avian curators managing collections where long term successful breeding had been achieved with ground-hornbill species. The author also conducted first hand behavioural observations of a number of captive ground-hornbills, particularly comparing Southern Ground-Hornbills between zoo exhibits of adult pairs without chicks and examples of zoo exhibits of well-established extended family groups of this species.

Problems identified

Upon review of the information collected through the investigation steps, five main problem areas were identified.

1) The importance of extended family cooperative breeding behaviour had been significantly underestimated for the Southern Ground-Hornbill.
2) For some zoos, the exhibit cage space and holding facilities were a potential limiting factor for successful breeding. Also, clearer guidelines for nest site provision could improve the chances for successful breeding.
3) Some individual birds were being used in education presentation programmes and holders were unwilling to move them to meet breeding recommendations.
4) There were examples of zoos trading their captive bred ground-hornbills outside of the SSP population.
5) Many recommended pairings were not breeding successfully with a variety of causes (including pairing criteria, recognizing key behaviours, etc.) contributing to this lack of success.

Recommendations

The husbandry and cage space requirements survey produced a large amount of useful information that is now used for the development of husbandry guidelines and an animal care manual, as well as being shared in several publications still being prepared on different specific aspects on the management of ground-hornbills in zoos (Sweeney 2013). However, the most important results were quickly identified and the following recommendations were set out in a presentation about the challenges

of these populations during a sustainability challenges workshop at the national AZA conference in 2010 (Sweeney 2010).

1) Encourage zoos to prioritize exhibit space and holding facilities for Southern Ground-Hornbills, given their conservation status and population sustainability challenges compared to the Abyssinian Ground-Hornbill.
2) Encourage zoos keeping Southern Ground-Hornbills to form family groups. This became an expectation for all zoos participating in the SSP from 2011 forward (Sweeney and Lynch 2011).
3) As an extension to the recommendation for zoos breeding Southern Ground-Hornbills to form family groups, it was also stressed that juveniles should remain with the parents and not separated into young pairings too early in order to avoid potential sibling effect relationships being formed. Female juveniles should remain within the group for two years, or until any signs of displacement are observed, male juveniles should remain within the group for at least five years and ideally gain experience acting as a nest helper before being separated and moved into a pairing situation.
4) Information gathered from the above actions was used towards producing a draft Animal Care Manual for ground-hornbills.
5) Continue research to identify key aspects of behaviour, pairing and breeding success. Certain key behaviours related to courtship display and maintaining social organization within a family group have been poorly understood in the past. The development of the animal care manual should help resolve this.
6) If Southern Ground-Hornbills need to be hand-reared, SSP participants should consider supervised re-introduction of those juveniles back to the parents pre-weaning using the protocol developed by San Antonio Zoo.
7) Seek solutions to valuable birds being lost or made unavailable for SSP breeding recommendations.

RESULTS

Since the recommendations in 2010 (Sweeney 2010) more zoos have moved towards keeping Southern Ground-Hornbills in extended family cooperative systems. The 2011 Southern Ground-Hornbill population analysis, breeding and transfer plan (Sweeney and Lynch 2011) clearly stated that it is now an expectation for zoos keeping Southern Ground-Hornbills to try and establish a family group.

The successful protocol developed by San Antonio Zoo, for the introduction of parent-reared chicks back into the parent's enclosure, has

now been very successfully replicated at the Potawatomi Zoo. Here, four hand-reared chicks have now been successfully introduced back to the parents pre-weaning and are now all part of a successful family group there.

Additional potential founders have now initiated breeding, becoming founders and contributing to the number of first generation birds. Some of the non-productive first generation birds have started to show increased breeding potential since they have become the focus of increased behavioural work.

Several projects to help test and quantify the significance of social learning are planned or implemented, including an important attempt to encourage breeding behaviour from a very genetically valuable first generation hand-reared female who has now been paired to a first generation male that was parent-raised and has observed breeding behaviour as a nest helper in a cooperative breeding family group.

DISCUSSION

From 2010 onwards the managed captive populations of ground-hornbills show improved performance against the population sustainability criteria currently used to assess zoo populations (Lacy 2009), although when considering these sustainability criteria, we should continue to look harder into the true purpose behind our decisions for maintaining captive populations and what zoo population sustainability truly means (Lacy 2013). Increasingly, an argument is made for zoological collections to prioritize resources towards selecting species to focus on where there is realistic opportunity to merge *ex situ* populations with in field conservation management, with such populations being managed based on the criteria that captive management is a short-medium term objective as a meta-population strategy that integrates with conservation management for the wild population; rather than attempting to maintain closed zoo populations indefinitely (Conway 2011; Leader-Williams et al. 2007).

Recent research (Kotze et al. 2012) now suggests that there may be enough differences between the southern population of Southern Ground-Hornbills from South Africa and the eastern population from Tanzania, potentially meaning that from a conservation standpoint they would be better managed genetically as separate populations. This raises several questions about how the zoo populations of Southern Ground-Hornbills in North America and Europe could best contribute to future field conservation management.

In addition to reassessment of the potential that zoo populations could contribute genetic and demographic benefit towards reinforcement of the wild populations under a future meta-population conservation management strategy, there is also potential for behavioural and biological research objectives from zoo populations. In the case of the Southern Ground-Hornbill, the significance of social learning of juveniles within an extended family cooperative breeding system has been noted in both zoo management and by field researchers with the Mabula Ground Hornbill field conservation program. As the Mabula Ground Hornbill Project builds upon a successful reintroduction program, the potential exists for zoo populations to help test experimental parameters as future research questions are developed to further assess social learning and adaptive behaviour in juveniles, as well as providing easy access to build knowledge on basic biological values.

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Table 1. Data from 2010 assessment of the ground-hornbill populations in North American Zoos.

Species	Abyssinian Ground-Hornbill	Southern Ground-Hornbill
SSP living populations in 2010	70 (35♂♂, 35♀♀)	105 (48♂♂, 56♀♀, 1 unsexed)
Founders/potential founders in SSP	45 (2 still alive)	92 (42 still alive)
Founders that had bred	14 (31%)	20 (21%)
Captive bred birds	68	61
Captive bred birds that have bred	37 (54%)	2 (3%)

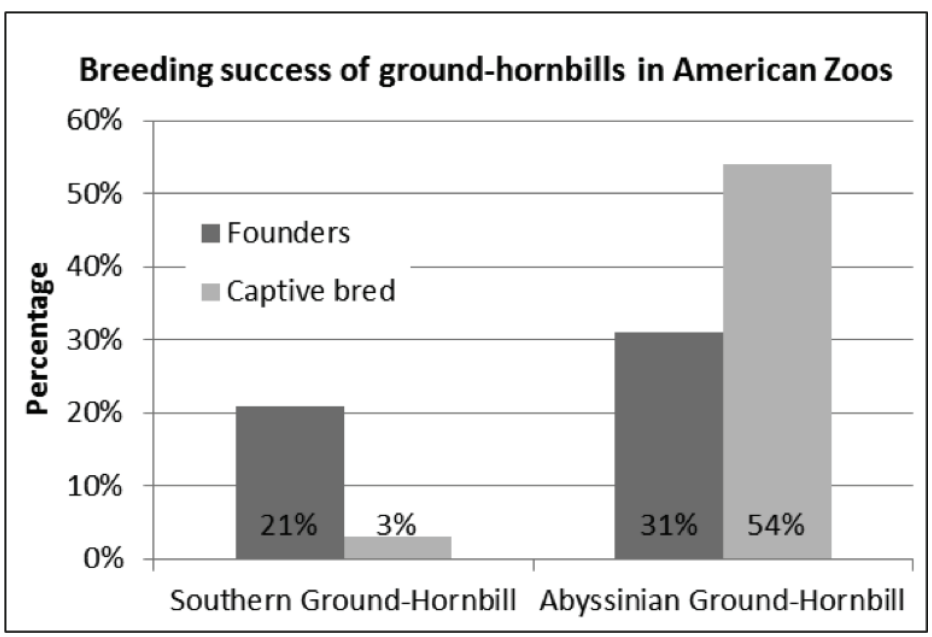

Figure 1. Percentage of founders and first generations birds in North American zoos that had demonstrated successful reproductive behavior for both Abyssinian and Southern Ground-Hornbills, assessed in 2010.

Observations on the breeding biology of Wrinkled Hornbill *Aceros corrugatus* Temminck, 1832 in Bala forest, Narathiwat, Thailand

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Abstract: Wrinkled Hornbills *Aceros corrugatus*, believed to be extinct in Thailand's rainforest, were rediscovered in 2006. This is the first study on the breeding biology of this species in Thailand or elsewhere. A nesting pair of Wrinkled Hornbills was observed in Bala forest, Narathiwat during March-June 2012. The total observation time was 504 hours. The diet consisted of 34% figs, 43% other fruits, 9% invertebrates, 1% vertebrates and 13% unidentified food items. The male started to feed the female on meat in the fourth week. The maximum feeding frequency was 59 times. The period of maximum feeding frequency was during 0800-0959 hours and the lowest frequency was during 1600-1800 hours.

Keywords: Wrinkled Hornbill, *Aceros corrugatus*, observation, breeding biology, Bala forest

INTRODUCTION

The Wrinkled Hornbill *Aceros corrugatus* is a resident of the primary lowland evergreen and swamp forests in the Thai-Malay Peninsula, Sumatra and Borneo. Its current IUCN Red List status is Near Threatened (BirdLife International 2001). The population is rapidly declining because of habitat destruction, especially the primary lowland evergreen forest. The species is believed to be extinct in Thailand as it has not been recorded for a long time (Vidhidharm et al. 1995). This is the first study on breeding biology of the Wrinkled Hornbill in Thailand.

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MATERIALS AND METHODS

The study was conducted from March to June 2012 in Bala forest (5˚48' N, 101˚48' E), a primary rainforest at 200 m asl near Halabala Wildlife Research Station, Narathiwat province, Thailand. Observations were made three times a week during the daylight hours for a total of 504 days over a 10-week period. The time of arrival and departure of each visit of the male and the number and types of food items delivered were noted. Observations were made from a blind on the ground at a distance of 30 m from the nest tree using 20-60x telescopes.

RESULTS

General observations

The nest hole was located in a living tree (Family Dipterocarpaceae) at about 12 m above ground, with the opening slit directed toward the northeast (47^{o}). The nest was found on 28 February 2012 but observations only started on 9 March 2012. The female had already closed the nest more than a week before the nest was found.

Feeding observations

The average frequency of feeding was 7.33 times per day. Before feeding, the male always stayed for a short period on a nearby branch. He passed the food items to the female and chick 2-4 times during each visit. The highest frequency of feeding was in the morning between 0800-0959 hours and the lowest between 1600-1800 hours (Figure 1). The food consisted of 34% figs, 43% other fruits, 9% invertebrates, 1% vertebrates and 13% unidentified food items, of which fruits made up 77% (Figure 2). The male started feeding the female on animal items in the fourth week (Figure 3).

DISCUSSION

The main diet of *A. corrugatus* is fruits, together with some vertebrate and invertebrate prey, similar to that of *A. waldeni*. (Kauth et al. 1998). The male started feeding his family with animal foods in the fourth week as these are an important protein source for the female and the growing chick(s).

The breeding season of *A. corrugatus* in this study was between February and June, which is different from the previous study in 2005 where the breeding season at two nests was reported to be between June

and September (Thong-Aree 2005). Availability of food is suggested as the cause of the different breeding seasons in the two studies. After all, the birds must raise their chicks during periods when most of their fruit plants are fruiting (Poonswad et al. 1999). In 2012, the dry season in this area came early, thus resulting in the early fruiting of these trees and as a consequence the early breeding season.

ACKNOWLEDGEMENTS

We thank the staff of the Halabala Wildlife Research Station for assistance in the field. We are grateful to Professor Pilai Poonswad, Siriporn Thong-Aree and Thailand Hornbill Project for supporting the study of hornbills in Halabala Wildlife Sanctuary.

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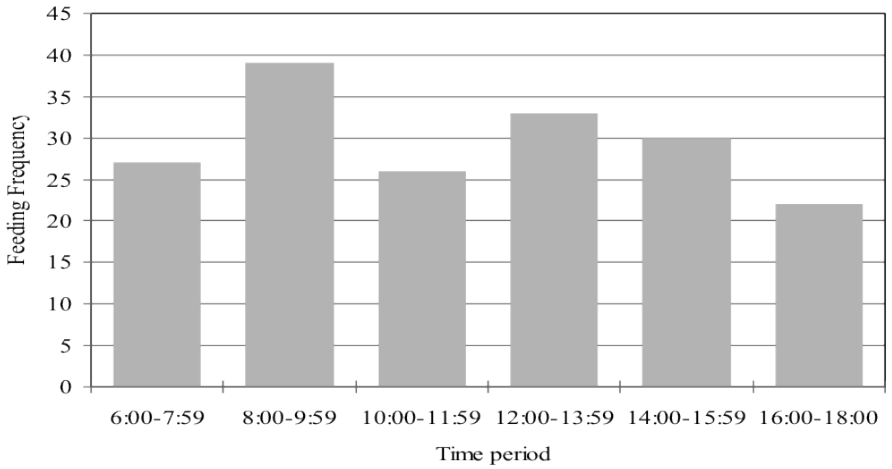

Figure 1. Feeding frequency of male Aceros corrugatus during daylight for the whole observation period.

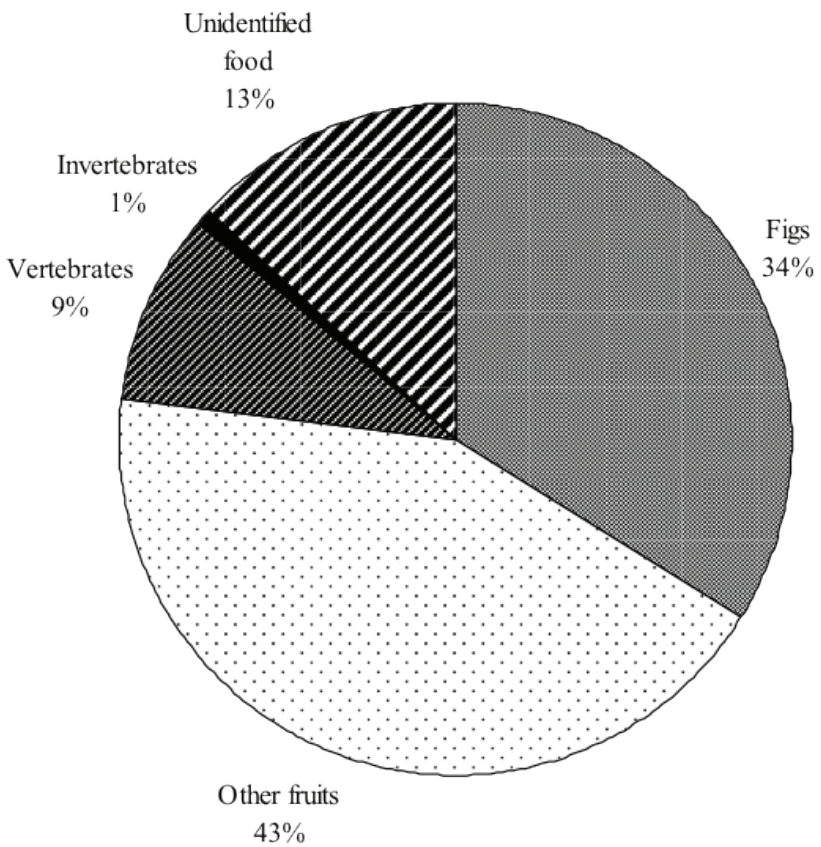

Figure 2. Diet of Aceros corrugatus as delivered at the nest.

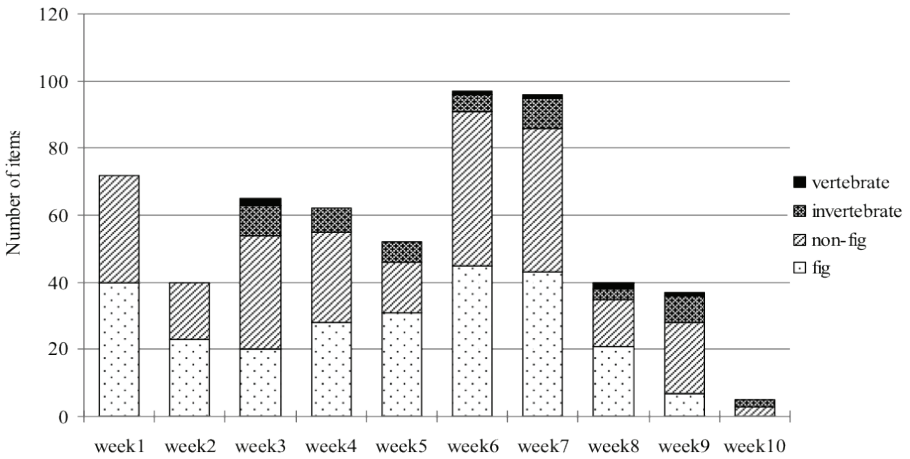

Figure 3. Food items that the male delivered to the nest in each week.

Philippine hornbills' conservation status: problems and prospects

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Abstract: Philippine hornbill species comprise over 16% of the global Bucerotidae (Aves: Bucerotiformes), a charismatic group of tropical Afro-Asian birds. All 15 taxa (species and their subspecies) in the Philippines are endemic to the archipelago, often restricted to rain forests of a particular island or faunal region. Currently, half of the known hornbill species in the Philippines are regarded as threatened (IUCN 2012). Proposed taxonomic changes in hornbills follow a recent comprehensive molecular phylogenetic analysis of Bucerotidae (Gonzalez 2012), and re-evaluation of species limits based on the application of new criteria (Tobias et al. 2013). These proposed changes have elevated three taxa of Philippine hornbills to full species status, thus restricting their respective areas of occupancy. We evaluate the applications of these taxonomic changes and present revisions in their conservation status, based on IUCN categories. In this paper, we enumerate the implications of these revisions for the re-launching of the Philippine Hornbills Conservation Programme, focusing on problems and prospects in the action plans for priority conservation areas. These priority areas represent key island groups/faunal regions for endemic and threatened hornbills, including the West Visayas faunal region, Polillo group, Mindoro, Calamianes group, Greater Mindanao faunal region and Sulu islands.

Keywords: Philippines, hornbills, Bucerotiformes, conservation, molecular phylogenetic, mitochondrial DNA

INTRODUCTION

Hornbills (Order Bucerotiformes) are a charismatic group of tropical birds, characterized by syndactyl feet, a distinctive casque on the bill and a unique trait of plastering the entrance of their nest cavity (nest-sealing). They comprise two families, Bucorvidae and Bucerotidae with a total of 54 species in 76 taxa distributed across Africa and Asia (Kemp

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2001; Figure 1). Taxonomic revisions subsequent to Kemp (2001) have recognized 88 taxa in 61 species known worldwide (Gill and Donsker 2012). Asian hornbills represent 32 species distributed from India to the Solomon Islands (Table 1), and are considered to be largely obligate frugivores, thus important dispersers of rainforest seeds (Kinnaird and O'Brien 2007). From this total, nine species of Asian hornbills are categorized as threatened and 6 as Near Threatened (IUCN 2012). Some nine species are endemic to the Philippines, of which more than half (five) are currently threatened, including two that are regarded as critically endangered, such as the enigmatic Sulu Hornbill *Anthracoceros montani.*

A recent comprehensive study on the evolution of Bucerotidae (Gonzalez 2012) addressed several key points raised during the 5th International Hornbill Conference 2009 held in Singapore, focusing particularly on the keynote paper presented by Kemp and Kemp (2009). They noted the importance of re-evaluating species limits among hornbill taxa based on modern phylogenetic techniques, of which a consensus phylogeny was presented based mainly on the use of morphology (Kemp 1995) and analysis of the mitochondrial DNA (mtDNA) Cytochrome *b* (Cytb) gene (Hübner et al. 2003). Kemp and Kemp (2009) emphasized the questionable status of several taxonomically enigmatic species, including the dwarf hornbills (*Tockus*), Long-tailed Hornbill (*Tropicranus*), Helmeted Hornbill (*Rhinoplax*), small Indian hornbills (*Ocyceros*) and the Sulu and other Philippine hornbills. Alongside this need for further phylogenetic analysis, they also enumerated gaps in overall biology and ecology of both West African and Philippine hornbills, as well as outlining the ethno-biological importance of hornbills worldwide.

A pioneering study by Sibley and Ahlquist (1990) established the evolutionary relationships of birds using DNA-DNA hybridization techniques, and constructed one of the first molecular phylogenies of hornbills based initially on 17 species. This study was followed by that of Morin et al. (1994), who constructed a tree of seven species based on short sequences of mtDNA Cytb, and this was later expanded by Srikwan and Woodruff (1998) to include 11 hornbill species. Consequent phylogenetic trees were built on the established mtDNA Cytb sequences, and were expanded to include 22 species (Hübner et al. 2003) and then 34 species, thereby covering all known hornbill genera (Viseshakul et al. 2011). A more comprehensive molecular phylogeny of hornbills by Gonzalez et al. (2013a) covered all 61 known species of Bucerotidae.

Gonzalez et al. (2013a) addressed the taxonomic changes of hornbills at the generic and species level, but did not address issues at the subspecies or population level. However, they were able to sort out questions regarding evolutionary relationships mentioned by Kemp and Kemp (2009) such as the placement of dwarf hornbills, Long-tailed Hornbill, Helmeted Hornbill, small Indian hornbills and the Sulu

Hornbill. All nine Philippine species and the Samar Hornbill *Penelopides samarensis* were included in Gonzalez et al. (2013a), but additional subspecies from the Philippines were not tackled. Those were covered in two chapters in Gonzalez (2012) that focused on the phylogenetic analysis of all known subspecies of Asian hornbills, and a comparison of genetic and phenotypic divergence. Given these recent developments in the molecular and morphological analysis of Philippine hornbills, we apply the taxonomic revisions proposed by Gonzalez (2012) and Gonzalez et al. (2013a) as a basis for re-evaluating their conservation status. This paper also aims to discuss the consequential problems and prospects for developing action plans and re-directing conservation priorities for Philippine hornbills.

MATERIALS AND METHODS

The application of proposed changes in the taxonomy of Asian hornbills followed the recent study made by Gonzalez (2012) based on both molecular and morphological analysis. Proposed taxonomic changes were compared with the current IUCN (2012) threat status, and re-evaluated using the criteria set by IUCN based on consequent changes in population density, area of occupancy and present state of occupied habitats. Revisions in the conservation status of hornbills reiterate the importance of the Philippines as a global conservation priority, given that half the species are already regarded as threatened. Gonzalez (2012) constructed a comprehensive phylogeny of Asian hornbills based only on mtDNA Cytb and covered nearly all known geo-isolates (subspecies and island populations). A total of 78 taxa with 120 geo-isolates were included and placed emphasis on geo-isolates from the Philippines.

Molecular and phenotypic divergence was determined between pairs of geo-isolates as a basis for evaluating species limits. Proposed changes in taxonomy were largely based on this revised phylogeny and a corresponding pre-published chapter combining genotypic and phenotypic data to address the question of species limits in 54 pairs of Asian hornbills (Gonzalez et al., in prep). Phenotypic delineation was based on the criteria used for delimiting bird species established by Tobias et al. (2010). Cumulative scores for morphology, acoustics, behaviour and distribution were used to determine phenotypic divergence, based on the scores crossing beyond the threshold of 7. Molecular divergence was based on the model-fitted analysis of genetic distance using mtDNA Cytb (Fergin et al. 2012) and based on the scores crossing beyond the mtDNA divergence threshold of 4 (Price 2008).

RESULTS AND DISCUSSION

Recent proposed changes to the taxonomy of hornbills were discussed in Gonzalez (2012), which were published in two corresponding papers, describing the molecular phylogeny of Bucerotidae (Gonzalez et al. 2013a) and the subsequent corrigendum (Gonzalez et al. 2013b). Further proposed taxonomic changes were based on comparison of phenotypic scores and molecular divergence (Gonzalez et al., in prep). In this paper, Philippine hornbills were grouped into four distinct clades, with a total of 15 species and subspecies recognized (Figure 2). The Buceros clade is sister to other Asian *Buceros* (*B. bicornis* and *B. rhinoceros*) and comprises two species, the nominate *B. hydrocorax* from northern Luzon and *B. mindanensis* from southern Philippines. Kemp (1995) suggested splitting the Rufous or Great Philippine Hornbill but refrained from doing so given insufficient information. Molecular analysis indicated all three subspecies were genetically divergent, but *B. mindanensis semigaleatus* was retained as a subspecies since the phenotypic score was insufficient to consider splitting the two populations.

The *Aceros* clade included two Philippine species, *A. leucocephalus* and *A. waldeni*, which were found to form a cluster with *A. corrugatus* and *Penelopides exarhatus*. Given that *Aceros* was polyphyletic, Gonzalez et al. (2013a) suggested placing the writhed-hornbills in their own genus *Cranobrontes* (Riley 1921) joined by *P. exarhatus*, which shared similar use of the oil gland and produced a staccato call. Gonzalez et al. (2013b) reconsidered using the genus *Rhabdotorrhinus* (Wiglesworth 1895) given its seniority over *Cranobrontes*. Since the *Penelopides* clade was now polyphyletic, resurrection of *Rhabdotorrhinus* returned *Penelopides* into an endemic Philippine genus. Molecular and morphological divergence supported the split of *Penelopides panini*, which was previously considered as one polytypic species (Kennedy et al. 2000). Nominate *P. panini* from West Visayas was distinct from *P. manillae* from Greater Luzon, *P. mindorensis* from Mindoro and *P. affinis* from Greater Mindanao. Data further supported the split of *P. samarensis* and *P. basilanicus* from *P. affinis*. Genotypic and phenotypic scores also support retention of polytypic taxa, *P. panini ticaensis* and *P. manillae subniger*, both of which approach the threshold of 7 in the Tobias et al. (2010) criteria, but not enough to be elevated to full species.

An evaluation of the *Penelopides* clade within the comprehensive mtDNA Cytb tree indicated clustering of subclades based on related geo-isolates, including the clustering of Ticao with Masbate hornbills, thus suggesting the close relationship of the functionally extinct Ticao Tarictic Hornbill *P. panini ticaensis* to the nominate Visayan Tarictic Hornbill *(P. p. panini)* from Masbate. The island endemic *P. affinis*

basilanicus from Basilan also formed a subclade with the nominate *P. a. affinis* from Zamboanga Peninsula. Subsequent subclade formation within known clades of a particular species may suggest incipient taxa, and are sometimes regarded as Evolutionary Significant Units (Sutherland 2000). These include clustering between Northern and Southern Luzon populations of *P. m. manillae*, and Eastern and Western Mindoro populations of *P. mindorensis*, as well as clustering of *P. p. panini* between Panay and Negros-Guimaras.

The *Anthracoceros* clade is represented by two species in the Philippines, and represents the most recent arrival in the archipelago. As an Asian clade, *Anthracoceros* still has unresolved relationships with *Ocyceros* from India and Sri Lanka. However, the enigmatic Black Hornbill *A. malayanus* is sister to a monophyletic clade of "Pieds", which includes *A. marchei* and *A. montani*. Much like geo-isolates in the *Penelopides* clade, there are emerging subclades within *A. marchei* such as clustering of populations from Balabac, Palawan and the Calamianes group.

Both published and unpublished proposed changes in the taxonomy and phylogenetic relationships of geo-isolates of Philippine hornbills reveal implications for their conservation – in particular, changes to their conservation status.

A summary of proposed revisions to the conservation status of Philippine hornbills is presented concurrently with the re-launching of the Philippine Hornbills Conservation Programme. Current taxonomy and conservation status (IUCN 2012) are enumerated in Table 1, along with the corresponding revisions. These revisions accepted the elevated species status of three Philippine Hornbills, thereby increasing the total of species from nine to 11. The Rufous or Great Philippine Hornbill *Buceros hydrocorax* is split into two species, and the Mindanao Tarictic Hornbill *Penelopides affinis* is split into three species. These splits result in a reduction in area of occupancy of the elevated taxa, and a corresponding elevation in conservation status. Both the Great Luzon Hornbill *B. hydrocorax* and Great Mindanao Hornbill *B. mindanensis* are considered Vulnerable, elevated from Near Threatened prior to the split. Both the Mindanao Tarictic Hornbill *P. affinis* and Samar Tarictic Hornbill *P. samarensis* are considered Near Threatened, with the Basilan Tarictic Hornbill *P. basilanicus* placed as Data Deficient, all elevated from Least Concern prior to the split.

On the other hand, both the Luzon Tarictic Hornbill *P. manillae* and Visayan Tarictic Hornbill *P. panini* are retained as polytypic, and their conservation statuses retained. However, important considerations are needed concerning their corresponding subspecies, since the Ticao

Tarictic Hornbill is now functionally extinct and the Polillo Tarictic Hornbill is definitely threatened. Given the novel findings about the close relationship between Masbate and Ticao hornbills, it is likely that surviving hornbills on Masbate should be regarded as Critically Endangered.

Both geo-isolates from Polillo and Masbate represent taxa that require further deliberation, since the application of the IUCN categories is unsatisfactory at a 'species' level. Five other species are retained as monotypic, and the conservation status of four hornbills is more or less retained (IUCN 2012) – all of which are threatened. This includes the Mindoro Tarictic Hornbill *P. mindorensis*, Visayan Writhed Hornbill *Rhabdotorrhinus waldeni*, Palawan Hornbill *Anthracoceros marchei* and Sulu Hornbill *A. montani*. However, there is the exception of the Mindanao Writhed Hornbill *R. leucocephalus* where a recently observed decline in the wild population suggests elevating its status from Near Threatened to Vulnerable.

Philippine Hornbills Conservation Programme

The Philippine Hornbills Conservation Programme (PHCP) was developed under the auspices of the Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR), and is now re-launched in collaboration with the Philippine Biodiversity Conservation Foundation Inc. (PBCFI) and other national and international conservation agencies (Oliver and Wilkinson 2007). Important revisions in the current PHCP Proposed Conservation Action Plan for the next five years (2013 – 2018) are enumerated in the following section, further describing the key areas representing Regional Conservation Action Priorities (Figure 3). The renewed PHCP is accompanied by a covering Memorandum of Agreement (MOA) between DENR, Vogelpark Avifauna and the North of England Zoological Society. The '2013-2018 Action Plan' is attached as an 'annex' to the MOA, thereby also indicating the compliance and support of all signatory parties for the following priority activities. The revised PHCP includes a review of conservation status categorizations and consensually agreed conservation research and practical management interventions for all hornbill species; thereby including the new taxonomic arrangements proposed by Gonzalez (2012) and its correspondingly increased numbers of recognized taxa at both species and subspecies levels (Table 1).

Currently proposed species (regional) conservation action priorities West Visayas Faunal Region (in close collaboration with all existing and potential new partner agencies)

- Re-evaluate current conservation status and likely future conservation management priorities for '*P. p. ticaensis*', which taxon was formerly known only from Ticao Island (where now 'extinct'). However, following Gonzalez (2012) potential re-assignment of tarictics from the neighbouring, larger island of Masbate (formerly 'lumped' with *P. p. panini* from other West Visayan Islands) to *P. p ticaensis*, it seems this subspecies may be still extant; albeit 'Critically Endangered'. Leastways, Paguntalan et al. (2004) reported the continuing occurrence of small numbers of tarictics in one or more badly fragmented and degraded mixed mangrove and secondary forest patches in one or more locations with this habitat in southwest Masbate.
- Assist salient local authorities to develop a new Local Conservation Area (LCA) network or similar habitat protection and restoration strategy in Masbate, together with associated development of salient conservation management plans, para-legal and other personnel training, and local community forest wardening schemes and awareness campaigns.
- Develop and extend on-going LCA developments in central-east Negros (Oriental) and extreme south-west Negros (Occidental), later extending to selected locations in west and northwest Panay Island, with a view to the increased protection of selected priority (especially non-NIPAS) terrestrial habitats (especially lowland forest, cave and wetland ecosystems) and endemic taxa.
- Complete on-going assessment of *A. waldeni* and *P. p. panini* population status (*i.e.* distribution, habitat utilization, approximate numbers and threats) in North Negros Natural Park (NNNP), as 'indicator' species for also evaluating (and hence duly strengthening) current forest management practices and protection activities in this and other NIPAS sites.
- Sustain, develop and extend existing conservation breeding programmes for *A. waldeni* and *P. p. panini* on Panay, Negros and elsewhere.
- Develop and implement properly structured reintroduction projects for *P. panini* and other threatened endemic species (possibly/hopefully including *A. waldeni*) in selected 'vacant' habitats on both Negros and Panay Islands, with a view to also strengthening existing IUCN (and DENR) guidelines per add-on biodiversity conservation values (*e.g.* greatly increased protection/restoration of existing habitats and wildlife, development of local community-based wardening and other activities,

and sustainable financing mechanisms – *e.g.* local government annual budgetary allocations and other support).

- Per all of above activities: investigate and, where possible, promote increased collaboration between key local stakeholders and other salient interest groups (e.g. academe); whether governmental, non-governmental, corporate or private.

Mindoro and associated offshore islands (in close collaboration with the Mindoro Biodiversity Conservation Foundation and other salient local partner agencies)

- Sustain and develop current 'protected areas' (including proposed new 'LCA' network), with development/expansion in selected priority (especially non-NIPAS) sites in Mindoro and associated islands (*e.g.* Ylin and Ambulong, but possibly extending to Lubang Island).
- Sustain and develop other biodiversity conservation-related activities, including local public education/awareness campaigns, teacher-training workshops, local community wardening schemes, *etc*.
- Conduct preliminary (and more detailed follow-up) surveys in other potentially important but barely, if ever, previously explored and biologically inventoried areas *(e.g.* Mt. Malasimbo. Mt. Baco), with a view to development of future (*i.e.* second phase) biodiversity conservation development plans and strategies.
- Investigate altitudinal distribution (as well as overall range) of key 'indicator' species, per implications for current and future 'protected area' developments in this (globally critical) region.

Polillo Islands (in close collaboration with the Polillo Islands Biodiversity Conservation Foundation and other local partner agencies)

- Complete current NewCAPP (New Conservation Areas in the Philippines Project) project activities, including establishment of new LCAs on Patnangungan and Jomalig Islands;
- Maintain and develop all other pre-existing and on-going LCA/habitat protection and restoration activities, local awareness, personnel training and other local institutional capacity-building activities on Polillo Island.
- Investigate options for assisting continued development of proposed new network of coastal and marine protected areas (MPAs).

Calamian Islands (in close with the Calamian Islands Biodiversity Conservation Support Group, Katala Foundation and other local partner agencies)

- Sustain and develop Phase Two and Three activities per establishment of a new network of 10 or more LCAs in selected priority sites on

Calamianes.

- Describe new species and publish other important findings resulting from recent field site surveys per the aforementioned LCA network development programme on Busuanga and Culion Islands
- Investigate options for assisting salient authorities to enhance salient protection and restoration activities in Calauit Island Game Preserve and Wildlife Sanctuary and other key (watershed, *etc*.) sites outside the proposed new LCA network.

Sulu Islands (in close collaboration Mindanao State University and other existing, and likely future partner agencies)

- Re-assess current status of *Anthracoceros montani* in Tawi-tawi, Batu-batu, Sanga-sanga and associated Islands (if possible also extending to Jolo and its associated islands), with a view to developing comprehensive conservation management plans for this and other key threatened endemic taxa.
- Conduct preliminary surveys on Sibutu Island (extreme southwest Philippines), which has seldom been explored biologically. This is of considerable potential interest as a separate late Pleistocene isolate, with likely strong faunal associations with Borneo, and such surveys also to be conducted with a view to formulation of follow-up conservation measures.
- Promote and develop local education-awareness campaigns, local personnel training and other institutional capacity-building schemes.

Greater Mindanao and associated 'higher conservation priority' islands (in close collaboration with salient local partner agencies – both governmental and non-governmental in each location)

- Camiguin Sur: To sustain and develop on-going field research, protected area (Mt. Timpoong - Mt. Hibok-Hibok Natural Monument) development and associated personnel training, local awareness campaigns, *etc*.; this island is of particular importance as a Pleistocene isolate, with several, new single-island endemic species so far described, plus as yet unexplained hiatuses (despite its close proximity to the Mindanao mainland) in the distribution of key regional endemics (*e.g. R. leucopcephalus* is present, but both *B. mindanensis* and *P. affinis* are absent).
- Dinagat and associated islands *(i.e.* Siargao and Bucas Grande): To conduct follow-up surveys and networking consultations with a view to the proposed development of a possible new LCA network of 'protected areas' on Dinagat Island, as a matter of some urgency; Dinagat-Siargao-Bucas Grande seemingly form a sub-center of species endemism within

the 'Greater Mindanao Faunal Region', likewise characterized by the occurrence of increasing numbers of new 'single island (or 'Dinagat/ Siargao/Bucas Grande only) endemic species, and similar absences of some other species (e.g. Philippine rusa, *Rusa marianus*), although all three Greater Mindanao hornbills, *B. mindanensis, P. affinis*, and *R. leucocephalus* are not only present, but this island constitutes the northernmost extension of their respective ranges. Unfortunately, however, Dinagat (wherein most native forest still remains) was long ago declared a mining reserve and virtually all remaining forested areas are now threatened by DENR-licensed mining claims, several of which are already active.

- Basilan Island: Unfortunately, Basilan (like Jolo and associated islands in east Sulu Archipelago) has been effectively off-limits to scientific research and associated conservation-related for the past half-century or so. This circumstance has naturally prompted increased concerns regarding current conservation status and future survival prospects of key hornbill and other various threatened (local and regional) endemic species populations; a situation now exacerbated by Gonzalez's (2012) separation of *P. basilanicus* as a single island endemic species. Whilst it is apparently unlikely that any concerted conservation interventions will be feasible in the near future, efforts should be made to acquire updated status data regarding this and key other species' populations, whilst also investigating any other feasible means of promoting increased local interest and concern per the future survival prospects of these taxa.

ACKNOWLEDGEMENTS

The authors would like to thank the organizers and sponsors of the 6th International Hornbill Conference, in particular the Wildlife Bird Club of the Philippines, Thailand Hornbill Research Foundation, Philippine Biodiversity Conservation Foundation Inc., Team Energy, Ayala Museum, Asian Institute of Management and PAWB-DENR. We also acknowledge the support of the Edward Grey Institute for Field Ornithology, University of Oxford, University of the Philippines Los Baños, as well as invaluable comments from Ben Sheldon, Joe Tobias, Nigel Collar, Roger Wilkinson, Andy and Liza Dans, Des Allen, Lisa Paguntalan, Godfrey Jakosalem, Carmela Espanola, Willem Van De Ven, Sol Pedregosa, Rob Hutchison, Ivan Sarenas, Errol Gatumbato, Mike Lu, Peter and Indira Widmann, Lucia Lastimoza, Norbert Bahr, Ed Dickinson, Ng Bee Choo, Anna Gonzales and Alan and Meg Kemp.

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Table 1. List of Asian Hornbills with proposed taxonomic changes based on Gonzalez et al. (2013a, 2013b) and Gonzalez et al. (in prep.), with emphasis on Philippine taxa.

Former Name	Former Threat Status	Proposed Name Change	Proposed Threat Status Change
Anorrhinus tickelli	Critically Endangered		
Anorrhinus austeni	Critically Endangered		
Anorrhinus galeritus	Critically Endangered		
Ocyceros griseus	Least Concern		
Ocyceros gingalensis	Least Concern		
Ocyceros birostris	Least Concern		
Anthracoceros coronatus	Critically Endangered		
Anthracoceros albirostris	Critically Endangered		
Anthracoceros marchei	Vulnerable		
Anthracoceros malayanus	Critically Endangered		
Anthracoceros montani	Critically Endangered		
Buceros bicornis	Critically Endangered		
Buceros rhinoceros	Near Threatened		
Buceros hydrocorax hydrocorax	Near Threatened	*Buceros hydrocorax*	Vulnerable
Buceros hydrocorax mindanensis	Near Threatened	*Buceros mindanensis*	Vulnerable
Buceros hydrocorax semigaelatus	Near Threatened		
Rhinoplax vigil	Least Concern	*Rhinoplax vigil*	
Penelopides exarhatus	Least Concern	*Rhabdotorrhinus exarhatus*	
Penelopides panini panini	Least Concern		IUCN category unsatisfactory at 'species' level

Former Name	Former Threat Status	Proposed Name Change	Proposed Threat Status Change
Penelopides panini ticaensis	Least Concern		
Penelopides manillae manillae	Least Concern		IUCN category unsatisfactory at 'species' level
Penelopides manillae subniger	Least Concern		
Penelopides affinis afinis	Least Concern	*Penelopides affinis*	Near-threatened
Penelopides affinis samarensis	Least Concern	*Penelopides samarensis*	Near-threatened
Penelopides affinis basilanicus	Least Concern	*Penelopides basilanicus*	'Data Deficient', but most likely 'Endangered'
Penelopides mindorensis	Least Concern		
Berenicornis comatus	Critically Endangered		
Aceros nipalensis	Near Threatened		
Aceros corrugatus	Least Concern	*Rhabdotorrhinus corrugatus*	
Aceros leucocephalus	Near Threatened	*Rhabdotorrhinus leucocephalus*	Vulnerable
Aceros waldeni	Critically Endangered	*Rhabdotorrhinus waldeni*	
Aceros cassidix	Least Concern	*Rhyticeros cassidix*	
Rhyticeros narcondami	Least Concern		
Rhyticeros plicatus	Least Concern		
Rhyticeros subruficollis	Least Concern		
Rhyticeros undulatus	Least Concern		
Rhyticeros everetti	Least Concern		

Figure 1. World map showing the distribution of extant and extinct hornbills across Africa and Asia (adapted from Kinnaird and O'Brien 2007).

Figure 2. Some threatened and endemic Philippine hornbills: (1) Visayan Writhed Hornbill *Rhabdotorrhinus waldeni* (Critically Endangered); (2) Great Mindanao Hornbill *Buceros mindanensis* proposed as Vulnerable; (3) Mindoro Tarictic Hornbill *Penelopides mindorensis* (Endangered); and (4) Palawan Hornbill *Anthracoceros marchei* (Vulnerable).

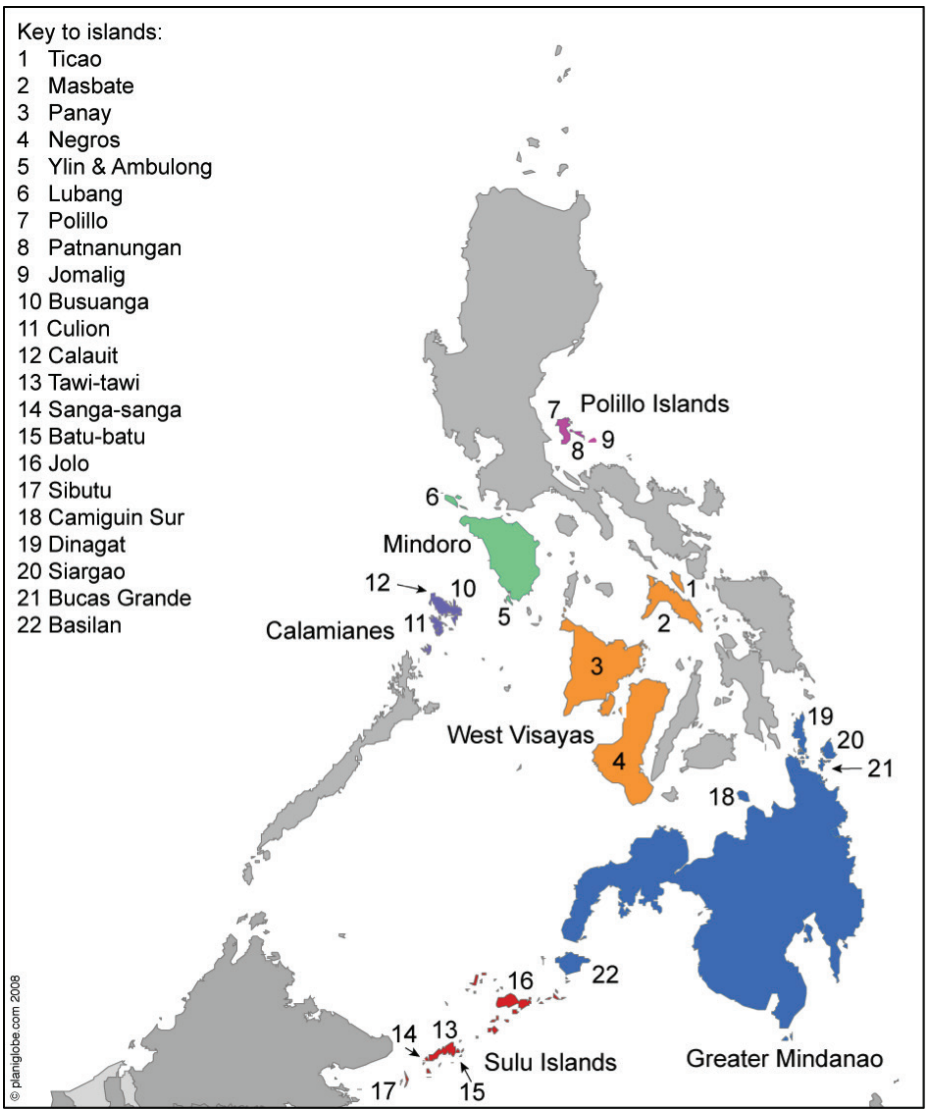

Figure 3. Map of the Philippines with emphasis on inclusive islands for proposed regional conservation action priorities based on revised Philippines Hornbills Conservation Programme (PHCP) 2013–2018.

Protecting a hornbill haven: a community-based conservation initiative in Arunachal Pradesh, northeast India

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Abstract: Pakke Tiger Reserve (PTR) in Arunachal Pradesh harbours four species of hornbills (Great Hornbill *Buceros bicornis*, Wreathed Hornbill *Rhyticeros undulatus*, Rufous-necked Hornbill *Aceros nipalensis* and Oriental Pied Hornbill *Anthracoceros albirostris*). Deforestation and hunting of hornbills are the two major threats to hornbill populations. However, due to protection efforts by the Forest Department and a ban on hornbill hunting since 2003, PTR and its surrounding forests still supports a healthy population of hornbills. A ten-year long-term monitoring of hornbill nests suggested that deforestation in the adjoining Papum Reserved Forest (PRF) which has a lower legal protection status continued to threaten hornbill populations. We also observed increased direct interference competition between hornbill species for nest sites. However, despite degradation, several Reserved Forests outside PTR provide a large area (*ca.* 1,280 km^2) of suitable habitat. Therefore, participation of the local community in protection efforts outside PTR was necessary for the long-term conservation of hornbills. Consequently, in 2012, a 'Hornbill Nest Adoption Program' was initiated in a three-way partnership between the Ghora-Aabhe Society (council of *Nyishi* village headmen), the Arunachal Pradesh Forest Department and the Nature Conservation Foundation. The main concept is shared parenting: biological parents (hornbills) look after their chicks, local guardians (*Nyishi* villagers, who were hunters previously) protect the nests and urban citizens provide financial support. Currently, nine villages on the southeastern boundary of PTR (in PRF) are participating in the program with eleven villagers working as nest protectors and one youth as local field coordinator. Over 90 urban citizens have supported the programme and we have raised over USD25,000 in two years (2012-2013). The funds are used to employ nest protectors, buy equipment, contribute to a village welfare fund and meet other project running costs. In the first season (2012), 28 nests of three species (Great, Wreathed and Oriental Pied Hornbill) were located, 17 nests were active, 8 nests were inactive and 3 were not visited. Of the 17 active nests, 11 were successful (65%

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nesting success). In 2013, 23 nests of three species were located from the nine participating villages with 12 active nests. Nesting success was higher in 2013 (91.6%). Three additional nests (one Great and two Rufous-necked Hornbills) were located in another village. From the data for the first two years, it appears that there are more Great Hornbill nests and that Great Hornbill nests are more successful in these outside areas. The reasons are unclear; however it is possible that most Great Hornbill nests are located in areas further away from human habitation within the Reserved Forest, while nests of Wreathed and Oriental Pied Hornbills are more prone to disturbance as they are situated in more degraded habitat with greater human activity/presence. We hope to collect long-term ecological information on nesting success and ensure conservation of hornbill nests and populations in the Reserved Forest and foster community involvement in conservation activities.

Keywords: *Anthracoceros albirostris, Buceros bicornis*, Hornbill Nest Adoption Program, *Nyishi* tribe, Pakke Tiger Reserve, *Rhyticeros undulatus*

INTRODUCTION

Pakke Tiger Reserve (PTR) is among the few Protected Areas in northeast India which support healthy populations of four sympatric hornbill species: Great Hornbill *Buceros bicornis*, Wreathed Hornbill *Rhyticeros undulatus*, Rufous-necked Hornbill *Aceros nipalensis*, Oriental Pied Hornbill *Anthracoceros albirostris* (Datta 1998; Dasgupta and Hilaluddin 2012). Following a four-year study on various aspects of hornbill biology and their role as seed dispersers (Datta 2001; Datta and Rawat 2003, 2004, 2008), we initiated long-term monitoring of hornbill nests and roosts inside PTR starting in 2003. Around 62 hornbill nests and three roosts have been monitored over a ten-year period in the reserve (Datta and Rane 2011a). The nesting success ranged from 80% to 100% in most years, except for 2005, when it was 62% (Datta and Rane 2011a).

Protection efforts in PTR have been strengthened since 2006 (Velho 2010; Velho et al. 2011) and anthropogenic disturbances to the habitat as well as hunting incidents for hornbills are rare, especially in the lower foothill areas (pers. obs.). Instances of nesting failure or nest abandonment were unrelated to human disturbances and we found no loss of nest trees due to cutting. Apart from this, a ban on hornbill hunting with heavy fines was instituted by a local Nyishi institution (Village Forest Development Council) set up in 2003 and reinforced later by the Ghora-Aabhe Society (council of village headmen) that was set up in 2006. Through another earlier program by the Arunachal Pradesh Forest Department in collaboration with the Wildlife Trust of India, people were

provided with substitute fibreglass beaks of the Great Hornbill to wear as part of their traditional headgear instead of real ones.

An analysis of our ten-year nest monitoring data showed that (1) the few nests that were monitored outside PTR in the Papum Reserved Forest (PRF) were usually abandoned due to human disturbance or the nesting trees were eventually cut down, (2) there was inter-specific competition for nest cavities with nest takeovers, which was not observed previously during 1997-2000 (Datta and Rane 2011a), and (3) there had also been tremendous loss of the foothill forest habitat in adjoining Assam from 1995-2005 and degradation of the forests outside PTR due to anthropogenic activities (Kushwaha and Hazarika 2004). Yet, the existing Reserved Forests in Arunachal Pradesh cover a large area (>1,000 km^2) and are important habitat for hornbills and need to be protected better. We tend to consider only Protected Areas as being important for wildlife, and often treat the forest areas outside as 'sinks' not worth considering. Lastly, our nest monitoring effort had not involved the *Nyishi* community, although we had earlier employed a few *Nyishi* in our research work. Our work had also been restricted to the lower elevation areas in PTR and we had not located any nests of Rufous-Necked hornbill, which occur only in the higher elevations (above 800 m asl). Therefore, there was a need to find a way to protect nests outside the park in the adjoining Reserved Forest, include villagers in the conservation effort and expand the scope and impact of the program for long-term protection of all the sympatric hornbill species in the area.

The 'Hornbill Nest Adoption Programme' was initiated in 2011. The idea was to initiate a community-run conservation programme, where there is people's participation in protecting their surrounding wildlife. Hunting, deforestation and fragmentation are the main causes of wildlife depletion; however until forest-dependent communities are aware and involved in conservation projects, there are limited chances of long-term success. The concept of adoption of hornbill nests is based on Dr Pilai Poonswad's hornbill conservation programme in Thailand, which has been running successfully for many years (Poonswad et al. 2005). The main concept is based on 'shared parenting'; Hornbill nests have three sets of parents: the biological parents (i.e. the breeding hornbill pair), the foster parents - the local guardians who monitor and protect the nests (the *Nyishi* villagers who were hunters before) and urban citizens who wish to financially support wildlife conservation and simultaneously understand conservation issues. The main objectives of this programme are to (1) ensure monitoring and protection of hornbill nests in the Reserved Forest (RF) area, (2) involve the local community in the protection effort, (3) obtain ecological data on hornbill nesting patterns and breeding success and (4) understand and address challenges in community-based conservation efforts outside Protected Areas.

MATERIALS AND METHODS

Study area

Pakke Tiger Reserve (PTR) (862 km^2; 26°54 – 27°16' N, 92°36' – 93°09' E) is located in western Arunachal Pradesh and is part of the Eastern Himalaya Biodiversity Hotspot. The elevation in the park ranges from 200 – 1,500 m asl. The climate is tropical with an annual rainfall of ca. 2,500 mm. The main forest type is tropical semi-evergreen. Towards the south and south-east, the sanctuary adjoins Reserved Forests and the Nameri Tiger Reserve (349 km^2) of Assam (Figure 1). To the east, lies the Pakke River and Papum Reserved Forest; to the west, it is bounded by the Bhareli or Kameng River, Doimara Reserved Forest and Eagle Nest Wildlife Sanctuary, and to the north by the Kameng River and the Shergaon Forest Division. Papum Reserved Forest (1,064 km^2), Doimara Reserved Forest (RF) (216 km^2) and Amartala Reserved Forest (west of Doimara RF) all fall under the Khellong Forest Division. The combined forested area covered by these Reserved Forests is 1,280 km^2. They are similar to PTR in terms of climate and forest type. However, they have been extensively logged in the past and resident forest-dependent communities harvest timber and non-timber forest produce from these forests. In addition, hunting has also been prevalent here (Sethi and Howe 2009). Parts of the Reserved Forests were converted to plantations and include villages and settlements. These forests together with PTR provide a large contiguous habitat to hornbills and other wildlife. Selective logging on a commercial scale occurred in Papum Reserved Forest until 1996 (Datta 1998).

Initiation of the conservation programme

The idea of the Hornbill Nest Adoption Programme was discussed with the Ghora-Aabhe Society and the park management of PTR in February 2011. There was a positive response and initially, it was decided to give an honorarium of Rupees 1000 (approx. USD17) for every nest that the villagers locate in PRF. By June 2011, three villagers had located eight nests (Datta and Rane 2011b). Subsequently, we had a meeting in late June 2011 with the Ghora-Aabhe members and the Arunachal Pradesh Forest Department to finalise a tripartite agreement to initiate the program fully from the breeding season of 2012. It was decided to involve nine villages along the southern boundary of PTR in the effort to protect hornbill nests in the adjoining PRF (Figure 2). The Ghora-Aabhe Society and the Village-level Welfare Committees had meetings to select a person from each village who would be the 'Nest Protector'. A *Nyishi* youth with formal education was selected to be the local field co-ordinator. A formal meeting was arranged on 28 November 2011. In this meeting, all nest protectors signed a formal confirmation in presence

of their respective village heads, on participation in the program. They also agreed on their job responsibilities. They were to work in groups of two (with the experienced people helping the younger ones), and start searching for nests starting in January every year. The nest protectors work for eight months (January to August), which encompasses the entire breeding season. Hornbill chicks fledge by July-August. The nest watchers have volunteered to locate and monitor new hornbill roost sites in the non-breeding season (September to February). Equipment (binoculars, shoes, leech socks, backpacks, field notebooks, pens, caps, raincoats), training in nest observations and a data recording and exposure trip was arranged for all nest protectors. The team is a mix of old, experienced people (ex-hunters) with knowledge of the forest (60-70 years) and of younger men (20-30 years) with formal education. In 2013, two more youth joined the team.

Field monitoring method

Hornbills in the area start nesting from mid-March and end by end-July to the beginning of August. Eighty-five percent of nest cavities are located in a single tree species; the emergent softwood *Tetrameles nudiflora* (Datta 2001; Datta and Rawat 2004). However, it is important to look for nests from January onwards as pairs will be seen flying around inspecting and cleaning potential cavities and engaging in courtship behaviour. Periodic visits were made to known nests during February-March to determine whether nesting had been initiated (visits by hornbill pairs, inspection and cleaning, followed by female entry and cavity sealing). New nest trees were located by intensive nest searches between February and May each year in a variety of ways: by following lone males, searching potential trees for cavities, locating middens (piles of regurgitated seeds and fecal matter below active nests), the presence of seedlings of hornbill food plants and old feathers, calls heard during watches at nearby nests, and/or observation of a male hornbill on a feeding visit to a cavity. We attempted to record the exact date of nest entry by the female through regular visits (every 1-3 days) during the initiation of breeding (March–April). Nest trees in which nesting had been initiated were checked occasionally throughout the breeding season to monitor if the nest had remained active. Nests in which there was no activity and no seal in the early part of the breeding season were not monitored after April. Some new nests were located in the middle of the breeding season. Towards the end of the breeding season (mid-June to August), we attempted to visit all nests in 2-3 days to obtain information on nest exit dates of female and chicks to obtain an estimate of length of nesting cycle, nesting success and number of chicks fledged. Overall nesting success was defined as the percentage of initiated nests that fledged young. However, not all nests could be monitored at regular and frequent intervals for obtaining exact

nest entry and exit dates. At some nests, chicks were observed coming out of the cavity. Where direct observations of chick emergence was not made, we inferred nesting success if the nest was active throughout the breeding season and the nest seal was found to be broken and opened at the end of the breeding season (July-August) or if a chick was observed in the vicinity of the nest tree with the adult hornbill pair.

RESULTS AND DISCUSSION

First season: January-August 2012

Nesting success

In the first season, 28 nests were located, of which 17 were active (pair occupied the nest cavity) and 11 were successful, while eight nests were inactive (Table 1). Three additional nests were not visited, either because they were far away and difficult to access in the monsoon or because they were found towards the end of the breeding season. As this was the first year, regular diary writing and intensive monitoring did not happen as planned for all the nests, therefore, a nest was recorded as successful if (1) chicks were seen outside the nest with both parents in July-August, (2) the male was, or the pair were, seen feeding chicks in the nest until mid-July or (3) the nest remained sealed and active until mid-July.

Out of the 28 nests, 11 were of the Great Hornbill. Out of these, nine were active, one inactive (Margasso) and one nest found in 2012 was not visited in 2012 for logistical reasons. Finally, seven nests were successful (87.5% success), and the outcome of one nest was unknown, as that nest was visited only once during the beginning of the season. Seven Oriental Pied Hornbill nests were found. One was inactive (Moboso 2), while six were active. However, only three nests were successful (50% success). Five Wreathed Hornbill nests were found; two were inactive (Jolly, Moboso 2), three were active and only one successful (33% success) (Table 2). Four other nests (Lanka) showed signs of use/activity from previous years but were inactive so we could not determine which species they belonged to (Table 2). The overall nesting success was 65%.

Five nests were unsuccessful; one Great Hornbill nest got burnt down during a forest fire (Darlong). A Wreathed Hornbill pair abandoned the nest tree during the forest fire, although the tree was not destroyed (Goloso). Two nest trees were cut down, one Wreathed Hornbill nest in Bali basti and one Oriental Pied Hornbill nest in Darlong. One Oriental Pied Hornbill nest was abandoned mid-way for unknown reasons (A2/ Moboso 1).

Nest entry and exit dates

The nests were observed more frequently during March-April and end of June to early August to record dates of female entry into the nest and chick exit from the nest. As this was the first year, we had some problems in getting all the nest protectors to write/record data and observations regularly and accurately on each visit they made. The breeding season for the Great Hornbill started between 2 and 22 March and ended between 2 and 31 July. Oriental Pied Hornbill started nesting from 10 to 14 April and they came out around 28 June to 4 July (Table 3). For the Wreathed Hornbill, nest entry and exit dates were missed.

Second season: January-August 2013

In the second season, we had 23 nests in total: eight Great, five Wreathed and ten Oriental Pied Hornbill nests (Table 4). Three additional nests, one of the Great Hornbill and two of the Rufous-necked Hornbill were reported by villagers from Lasung-pate, which was not part of the current nine participating villages in the programme (Table 5). Our team of nest protectors visited the area in July and found that at one nest, the chick had been killed, while the other nest was not shown by the villager as it was very far away. One Great Hornbill nest that was active near this village had also been partially cut which had resulted in nest abandonment by the pair, although the nest tree is still standing. Twelve nests were active (five Great, one Wreathed and six Oriental Pied Hornbill) in the main participating villages (Tables 4 and 5). Female entry into the nest took place between 18 March to 4 April for the Great Hornbill, on 21 March for the single Wreathed Hornbill nest and between 12 April and 29 April for the Oriental Pied Hornbill (Table 6). The success and exit date of chicks is given in Table 6.

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place between 18 March to 4 April for the Great Hornbill, on 21 March for the single Wreathed Hornbill nest and between 12 April and 29 April for the Oriental Pied Hornbill (Table 6). The success and exit date of chicks is given in Table 6.

In PRF, nesting was initiated in 17 out of 25 nests (68%) in 2012 (barring the three nests that were not visited), while in PTR in the same year; nesting was initiated in only 47% of nests (15 active and 17 inactive). Nesting success in PTR was 93% (14 out of 15 active nests) and much higher than that observed in PRF (65%). This is to be expected as, despite improved protection at nest trees, there are diverse human pressures in the area outside, with villages, settlements and resource-dependency of the local community. It is therefore unrealistic to expect 100% protection in the first year. Most of the nests that were unsuccessful (direct tree loss due to felling and fire) were also located very close to three villages, where it is more difficult to ensure protection. In addition, it is important to note that in total 11 nests were successful of which seven were of the Great Hornbill, which is more threatened and which used to be the main target of hunters in this area. The maximum number of nests observed was of the Great Hornbill and nesting success of its nests was very high in the PRF (87.5%). This indicates that despite the continuing problem of occasional felling of trees, the ban on hunting and the nest protection through this program has helped the species successfully breed in these forest areas outside PTR. It remains unclear why fewer nests of the Wreathed Hornbill have been located and why nesting success of this species has been much lower. It is possible that the Wreathed and Oriental Pied Hornbills are more adaptable species and may nest more often in locations/trees that are closer to villages which results in greater chances of them being cut down/disturbed.

In 2013, nesting was initiated in 52% of nests in PRF, while it was similar in PTR (51%). However, nesting success was much higher in PRF (91.5%) with 11 of 12 active nests having successful chick fledging, while in PTR it was 76.5%. There were also no direct losses/nest abandonments of active nests that are monitored by our nest protectors from the ten villages in the program. The higher success in the second year of the programme is an encouraging sign indicating that protection efforts are helping. After the loss of four nest trees in 2012, we had numerous meetings to discuss ways to prevent further losses to trees and ensure greater vigilance to detect and prevent fires and check tree felling. The nest protection teams have had discussions with their own community members in their respective villages to prevent instances of felling of nest trees and extracting wood/timber in the vicinity of existing nest trees. The two nests (one of a Great and Rufous-necked Hornbills

respectively) that have been affected by disturbance (felling and one instance of hunting) were located near a village (Lasung-pate) that is not yet a part of the programme and these nests were not monitored by our team. We hope to attempt a dialogue with them in the future, on curbing hunting and persuading them to join the nest protection programme.

CONCLUSION

While protecting hornbill nests and ensuring recruitment of hornbills every breeding season with a few villagers is an important first step towards starting a community-based conservation initiative, there are larger challenges with regard to ensuring habitat protection by the community in the long-term. Habitat degradation, weed invasion and deforestation due to anthropogenic activities continue to threaten Papum Reserved Forest. This also means resource (water, soil, firewood, bamboo, timber, non-timber forest produce) limitation for the human population in near future. There is a genuine dependency of the community on forests that needs to be addressed as there have already been instances of conflict with individual villagers over felling trees. The resident *Nyishi* community in the villages in most of PRF is supportive of conservation programmes. In April 2012, during an awareness campaign in Seijosa town, we initiated a discussion with the Ranger of the Territorial Division of the Arunachal Pradesh Forest Department and members of the Village Forest Development Council, Seijosa, about initiating a habitat restoration programme in PRF. This restoration programme would not only assist in improving hornbill and other wildlife habitat but also natural resources for villagers. We believe that the initiation of this programme would also result in greater appreciation of the importance of protecting the habitat. We also plan to use the funds for community welfare from the nest adoption program to address urgently felt needs of the larger community. We also plan to undertake a detailed socio-economic survey to understand their dependency on forest resources, development needs and attitudes and perceptions to wildlife. Unless people residing in and around forest areas understand conservation, decide to protect them and have a functional system in place for implementing conservation policies, long-term conservation of hornbills and other wildlife will be difficult to achieve.

ACKNOWLEDGEMENTS

We are extremely thankful to Mr. J.L.Singh (PCCF, Arunachal Pradesh), Mr.Tana Tapi (DFO, Pakke TR), Mr. P.B.Rana (Range Officer Pakke TR) and the Ghora-Aabhe members for their enthusiasm and continuous co-operation and support. This work would have not taken off, had it not been for the constant enthusiastic support, encouragement and guidance from Mr. Tana Tapi, who offered everyone unstinting support at all times despite his hectic schedule. We thank Takam Nabum (Chairman of Ghora-Aabhe) for helping us initiate the program with the Nyishi community. We thank Divya Mudappa for helping us in initiating the program and raising support from donors. We thank all our supporters and donors, without whose generous financial support this program would not have been possible. We thank Arati Rao and Samyak Kaninde for their enthusiastic help in several ways. We are grateful to Kalyan Varma and Samyak Kaninde for sharing their images of hornbills. We thank the nest protectors and other field staff (Kumar and Khem Thapa) for assistance in monitoring hornbill nests and roosts. We thank Rohit Naniwadekar, Karthik Teegalapalli for assistance in setting up this program and Swati Sidhu for helping with field work and other project activities. We are grateful to Smita Prabhakar and Naveen Raj at NCF for assistance in administration of the program. We thank R. Raghunath, NCF GIS analyst for preparing the maps of the area.

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Table 1. Nesting status and nest outcomes in 2012 for nine participating villages.

Village Name	Nest Protector	Number of Nest	Inactive	Not visited	Active	Successful
Jolly	Tajek Wage	5	1	0	4	4
Lanka	Suraj Bagang	6	4	2	0	0
Moboso 2	Pahi Tachang	6	2	1 (GH)	3	3
Margasso	Tajeng Tachang	2	1*	0	1	?
Goloso	Rungfe Paffa	2	0	0	2	1
A2	Tade Tok	1	0	0	1	1
Moboso 1	Gingma Tachang	1	0	0	1	0
Bali Basti	Taring Tachang	2	0	0	2	1
Darlong	Budhiram Tai	3	0	0	3	1
	TOTAL	**28**	**8**	**3**	**17**	**11**

* This nest tree got cut down subsequently in January 2013.

Table 2. Hornbill species breeding summary for 2012 season.

Hornbill Species	Number of Nest	Inactive	Not visited	Active	Successful
Great Hornbill	11	1	1	9	7
Oriental Pied Hornbill	7	1	-	6	3
Wreathed Hornbill	5	2	-	3	1
Not known	6	4	2	-	-
TOTAL	**28**	**8**	**3**	**17**	**11**

Table 3. Nest entry and exit dates for successful nests in 2012.

S. No	Village Name	Nest ID	Hornbill Species	Entry Period (by female)	Exit Period (by chick)
1	Darlong	GHD1	Great Hornbill	Between 18 and 22 March	Between 17 and 19 July
2	A2/Moboso 1	GHA/M1	Great Hornbill	between 15 March and 17 March	Between 2 and 10 July
3	Goloso	GHG1	Great Hornbill	between 18 and 21 March	Between 15 and 17 July
4	Moboso 2	GHM1	Great Hornbill	between 2 and 6 March	Between 10 and 14 July
5	Jolly	GHJ2	Great Hornbill	Mid-March	End July
6	Jolly	GHJ3	Great Hornbill	Mid-March	End July
7	Jolly	GHJ4	Great Hornbill	Mid-March	End July
8	Moboso 2	OPHM3	Oriental Pied Hornbill	Between 10 and 14 April	Between 28 June and 4 July
9	Moboso 2	OPHM5	Oriental Pied Hornbill	Not known	Between 28 June and 4 July
10	Bali Basti	*OPHB1	Oriental Pied Hornbill	Not known	Between 29 June and 2 July
11	Jolly	WHJ1	Wreathed Hornbill	March	Early August

*During initial visits, a pair of Wreathed hornbills were seen at the nest, cleaning and inspecting the cavity.

Table 4. Nesting status and nest outcomes in 2013 for 10 participating villages.

Village Name	Nest Protector	Number of Nest	Inactive	Active	Successful
Jolly	Tajek Wage	5	1	4	3
Lanka	Suraj Bagang	2	2	0	NA
Moboso 2	Pahi Tachang	6	3	3	3
Margasso	Tajeng Tachang	2	2	0	NA
Goloso	Rungfe Paffa	1	1	0	NA
A2	Tade Tok/Gingma Tachang	2	0	2	2
*Moboso 1	Ohey Tayem	1	0	1	1
Bali Basti	Taring Tachang	1	1	0	NA
Darlong	Budhiram Tai	2	1	1	1
*Taraboso	Vijay Tachang	1	0	1	1
	TOTAL	**23**	**11**	**12**	**11**

*Two new nest protectors joined the programme.
N/A = Not available

Table 5. Hornbill species breeding summary for 2013 season.

Hornbill Species	Number of Nest	Inactive	Active	Successful
*Great Hornbill	9	3	6	4
Wreathed Hornbill	3	2	1	1
Oriental Pied Hornbill	10	4	6	6
*Rufous-necked Hornbill	2	1	1	0
**Unidentified	2	2	0	0
TOTAL	**26**	**12**	**14**	**11**

*In July, one additional Great and two Rufous-necked Hornbill nests were reported by villagers in Lasung-pate which are included in the total count in this table, but were not under protection through the programme.
**Potential hornbill nest cavities shown by one nest protector in Lanka village, but not occupied.

Table 6. Nest entry and exit dates for successful nests in 2013.

S. No	Village Name	Nest ID	Hornbill Species	Entry Period (by female)	Exit Period (by chick)
1	Moboso 2	GHM1	Great Hornbill	1 to 5 April	Between 27 and 30 July
2	A2/Moboso 1	GHA/M1	Great Hornbill	18 March	17 July
3	Jolly	GHJ2	Great Hornbill	23 to 28 March	Between 1 and 3 July
4	Jolly	GHJ3	Great Hornbill	26 to 29 March	Between 1 and 3 July
5	Jolly	GHJ4	Great Hornbill	29 March to 3 April	Abandoned
6	Lasung-pate	GHL1	Great Hornbill	March	Abandoned
7	Jolly	WHJ1	Wreathed Hornbill	21 March	Between 27 June and 1 July
8	*Taraboso	OPHT1	Oriental Pied Hornbill	Before 20 April	Between 21 and 25 July
9	Moboso 2	OPHM3	Oriental Pied Hornbill	25 to 29 April	27 July
10	Moboso 2	OPHM4	Oriental Pied Hornbill	23 to 26 April	17 July
11	A2/Moboso 1	OPH A/ M2	Oriental Pied Hornbill	12 to 17 April	21 July
12	A2/Moboso 1	OPH A/ M3	Oriental Pied Hornbill	Before 15 April	2 August
13	*Darlong	OPHD2	Oriental Pied Hornbill	Found on 16 June	Between 3 and 8 July
14	*Lasung-pate	RNHL1	Rufous-necked Hornbill	Visited in July, but chick hunted	-
15	*Lasung-pate	RNHL2	Rufous-necked Hornbill	Reported by villager, but not confirmed	-

*New nests found this year. The Great Hornbill nest in Lasung-pate (reported by villager) was visited for re-check in July by our field staff and the nest tree was found partially cut and abandoned by the pair. The chick had been killed at one Rufous-necked Hornbill nest, and another reported Rufous-necked Hornbill (inactive) nest was not visited by our team.

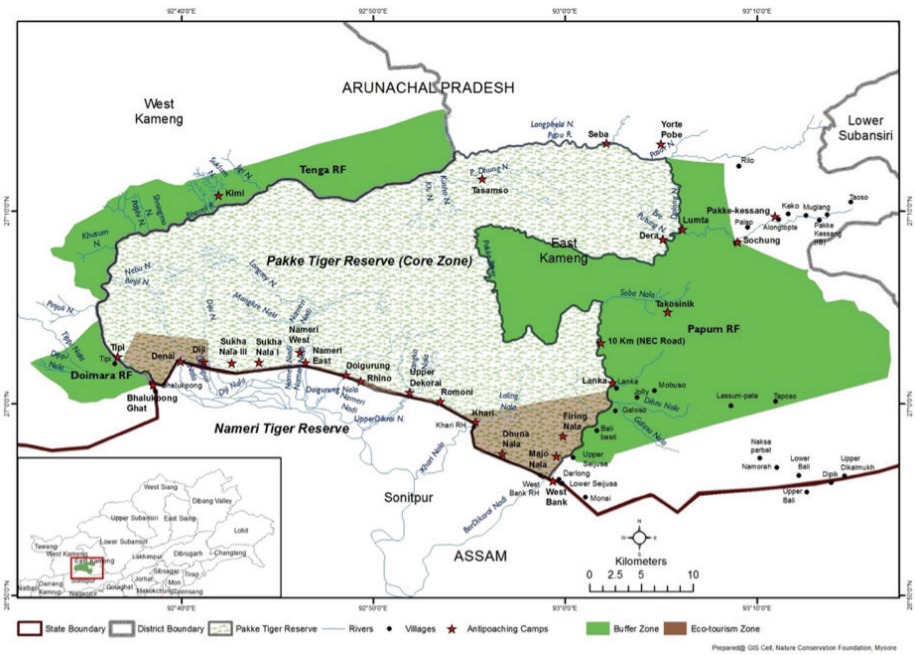

Figure 1. Map of Pakke Tiger Reserve, Papum Reserved Forest and other surrounding forest areas showing villages outside and Forest Department anti-poaching camps inside the reserve. Through the Hornbill Nest Adoption Programme, we are monitoring nests in nine villages in Papum Reserved Forest, while we continue to monitor hornbill nests inside the park since 2003.

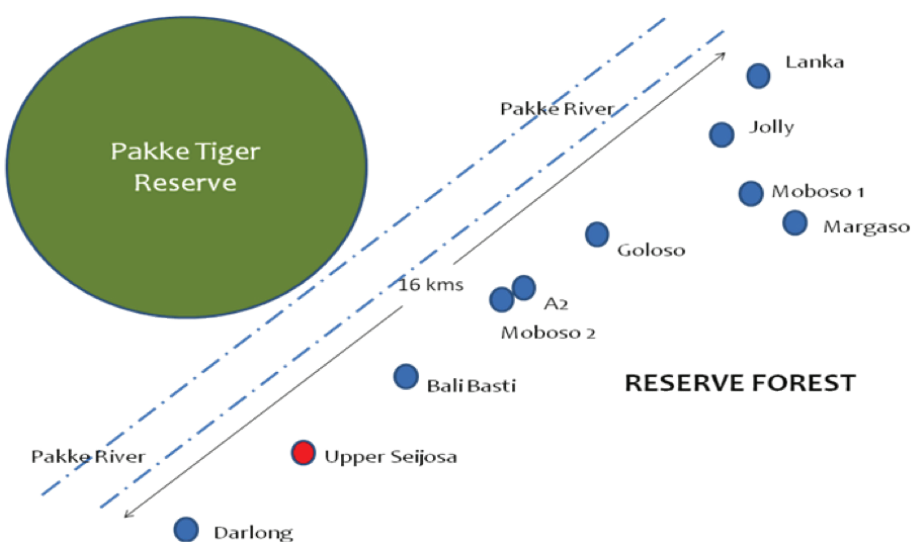

Figure 2. Schematic map showing villages (blue dots) around Pakke Tiger Reserve that are currently participating in the Hornbill Nest Adoption Programme.

Sarawak hornbill conservation initiatives – engaging the society

OSWALD BRAKEN TISEN[1*], SIM LEE KHENG[1] and FRANCIS GOMBEK[1]

Abstract: Sarawak, one of the Malaysian states on the island of Borneo, is known as the "Land of the Hornbills". It prides itself on having eight species of hornbills in its avifauna inventory. Hornbills play significant roles in the ecosystem of Sarawak's forests and the culture of its people. Such is the importance of hornbills to the extent that the Rhinoceros Hornbill is depicted in the State's emblem. A legal framework for the protection and conservation of hornbills is in place in Sarawak. Hornbill habitats are protected by the establishment of national parks and wildlife sanctuaries. The eight hornbill species found in Sarawak are also accorded protection by the law by being listed as "Totally Protected Species" under the Wild Life Protection Ordinance, 1998. However, information critical to hornbill conservation is lacking. Sarawak has taken steps to collect population status data by engaging various interest groups, including all park wardens, to inventorise hornbills in the State, especially in national parks. A hornbill workshop conducted in October 2012 brought together scientists, wildlife managers and interest groups to share their knowledge on hornbills. The information gathered thus far forms baseline data. Furthermore, the workshop recommendations provide guidelines for management and conservation of hornbills. Steps are now being taken to implement these recommendations.

Keywords: hornbills, Sarawak initiatives, society, conservation, Land of the Hornbills

INTRODUCTION

Sarawak, one of the Malaysian states on the island of Borneo, is also known as "Land of the Hornbills". With a land area of 124,449 km^2, and located between latitudes 0°50'-5°N, longitudes 109°36'-115°40'E, it has a high annual rainfall with no distinct seasons, and thus is covered with lush tropical rainforests. Sarawak shares its borders in the northeast with Sabah, another Malaysian state and with Kalimantan (Indonesia) in the south. Sarawak is ranked twelfth on the world's list of mega diversity areas. Its forest biomes include the highlands, coastal forests comprising

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freshwater swamps and peat swamps, hill forests and limestone forests. Of the 625 species (Smythies 1999) in its avifauna inventory, 50 are endemic to Borneo; which is approximately 8%, and eight are hornbill species. Sarawak has a population of 2,286,067 people from various ethnic groups and cultures (Department of Statistics 2013). There are 27 ethnic groups with the main groups being Malays, Chinese, and Dayaks.

Hornbills play significant roles in the ecosystem of Sarawak's forests and the culture of its people. Rhinoceros Hornbill is depicted even in the State's emblem. *Gawai Kenyalang*, literally meaning "Rhinoceros Hornbill Festival", is a big ceremony celebrated by one of the main tribes of Sarawak, the Dayaks. In the ceremony, a Rhinoceros Hornbill statue, which is thought to represent the chief of worldly birds, is used to welcome the god of augural birds, the *Singalang Burung*, to the feast in a celebration of humankind. The ceremony is considered the highest order of war ritual and held for several reasons (Datu N.S. pers. comm.); for victory over enemies or to arouse 'spirit beings' before going to war in the olden days. Hornbills are also featured in Orang Ulu (one of the ethnic groups) dances where each dancer is adorned with the tail feathers of Rhinoceros Hornbills. Old feathers were obtained from the wild in the past before State wildlife legislations were passed but in modern days, management authorities have obtained artificial feathers or turkey feathers to be used for this purpose. In the past, hornbill ivory carved from casques of Helmeted Hornbills was a valuable trade item, exported to China besides edible birds' nests (Smythies 1999). Today these are banned from being harvested as the helmeted hornbill is a totally protected species in Sarawak.

Hornbill conservation in Sarawak

Eight species of hornbills inhabit Sarawak's forests; the Rhinoceros *Buceros rhinoceros*, Helmeted *Rhinoplax vigil*, White-crowned *Berenicornis comatus*, Bushy-crested *Anorrhinus galeritus*, Wreathed *Rhyticeros undulatus*, Wrinkled *R. corrugatus*, Black *Anthracoceros malayanus* and Oriental Pied Hornbills *A. coronatus*. A legal framework for the protection and conservation of hornbills is in place in Sarawak. All eight are accorded protection by law, being listed as "Totally Protected Species" under the Wild Life Protection Ordinance, 1998 (Sarawak Government Gazette 1998). Hornbill habitats are protected by the establishment of national parks and wildlife sanctuaries with specific management prescriptions. Totally Protected Areas (TPA), comprising an area of 740,850 ha, include different categories such as Wildlife Sanctuaries, National Parks and Nature Reserves for the purpose of conservation, tourism, recreation and research (Figure 1). Timber harvesting is prohibited in these areas. Besides TPA, Permanent Forest Estates (PFE) have been established where controlled timber harvesting is permitted. PFE consist of Protected Forests (PF), Forest Reserves (FR)

and Communal Forests (CF). Even within an area where harvesting is allowed, an area of 100 m radius around salt licks and hornbill nest trees are not to be disturbed as clearly spelt out in the harvesting plan (Anon. 1996).

Sarawak initiatives

Sarawak recognises the importance of public involvement in conserving wildlife. The following projects are some examples of how society from all walks of life is being engaged in the conservation of hornbills.

(i) Hornbill surveys

Sarawak has embarked on surveys to collect population status data especially in TPAs since 2010. Various interest groups including park wardens have been engaged to inventory hornbills in the TPAs and elsewhere. The monitoring surveys will continue until sufficient information has been gathered on the hornbills in Sarawak. A hornbill workshop conducted in October 2012 brought together scientists, wildlife managers and interest groups to share their knowledge on hornbills. The information gathered thus far forms baseline data as shown in Table 1. In some parks, all eight hornbill species were recorded; in others, several or a few were recorded. Other aspects of hornbill conservation were also presented such as hornbills in captivity and the importance of hornbills in culture, tourism and conservation awareness.

(ii) Piasau hornbills

A hornbill monitoring project started some time in 2006 in a wooded residential area in Miri City, which was leased to Sarawak Shell Berhad. The monitoring was a collaborative effort of Sarawak Forestry, Sarawak Shell Berhad and the Malaysian Nature Society. A small population of Oriental Pied Hornbills was breeding in the area and this had caught the attention of the local people who in turn urged the government to establish a hornbill park in the area. A member of the public who is also an Honorary Wild Life Ranger has taken up the task of monitoring the nesting hornbills on a daily basis and updating information via Facebook for interest groups to follow (http://facebook.com/musa.musbah). The formation of this urban park has taken off and the earth breaking ceremony will be in May 2014. The pair of Oriental Pied Hornbills has been breeding here as early as 2006 and has been using the same site which has been well protected by residents in the area.

(iii) Hornbills in Santubong National Park

This is a component of the Sarawak Hornbill Programme for Santubong National Park, which is located in the vicinity of Kuching City. A small population of Rhinoceros Hornbills occurs here and the project is a

collaboration of major stakeholders; the State Government (Sarawak Forestry Corporation), local institutions of higher learning (Universiti Malaysia Sarawak) and a local resort proprietor (Permai Rainforest Resort). The presence of these stately birds in the park has aroused interest in developing the park as a hornbill-based ecotourism site whilst maintaining a sustainable population of birds. The team will continue to monitor the population to better understand the status of hornbills in the park and the limiting factors for long-term survival of hornbills in small protected areas such as Santubong National Park; as well as to determine possible ways to enhance their survival.

The Park which is a newly gazetted national park is now 'full-fledged' as recently Sarawak Forestry has placed management presence in the area. With that we should expect better visitor management as well as issues pertaining to law enforcement.

(iv) Kubah hornbills

Kubah National Park, about 22 km from Kuching City is another site of a hornbill monitoring survey. The project also looks into habitat improvement or rehabilitation of degraded areas by planting figs for the hornbills and other wildlife. The Bushy-crested and Black Hornbills have been recorded here. Hornbill surveys to understand their distribution are supplemented by surveys on the vegetation, so as to ascertain areas suitable for replanting fig trees. This project involves participation of personnel from various disciplines throughout the corporation, research groups, and park personnel.

(v) Mulu guides indicator programme

Gunung Mulu National Park in the northern region of the state of Sarawak is one of the oldest and largest national parks (Hazebroek and Abg Morshidi 2000). The park was inscribed as a "World Heritage Site" in 2000. As part of a monitoring programme, park guides participate in data collection on birds sighted while on the move. Data is entered in standardised data collection forms and park personnel assist in data collation, which has resulted in useful information on hornbills in the park.

(vi) Hornbills in captivity

Another aspect that is being considered is captive hornbills, although our emphasis is on in-situ conservation. There is indication of certain parties who are in favour of ex-situ conservation, to not discount confiscated birds, which are excellent subjects for conservation education. Matang Wildlife Centre has been established for confiscated wildlife, including

birds. Initially the Centre was set up solely for the rehabilitation of confiscated Orang-utans and personnel are involved in training the Orang-utans to fend for themselves in the wild. Captive hornbills, which had been confiscated or surrendered, are kept in Matang Wildlife Centre, and could be excellent candidates for conservation awareness as well as future release programmes.

(vii) Conservation awareness

It is recognised that any conservation programme is incomplete without awareness programmes. Examples of the programme are:

a) Special Parks Committee (SPC) and Special Wildlife Committee (SWC)

These are committees established at park level and within TPAs with functions in biodiversity conservation. Members consist of park personnel and representatives of local communities and interest groups. The roles of SPC and SWC are to assist in providing input for sound management of TPAs. They report issues such as poaching and encroachment within areas of their jurisdiction. Thus both SPC and SWC are channels for participative approaches in biodiversity conservation.

b) Honorary Wild Life Rangers (HWLR)

The subject of creating Honorary Wild Life Rangers (HWLRs) was first proposed in the 1980s by the Select Committee for Flora and Fauna of the State Legislative Assembly (Amin 2000). Under the Wild Life Protection Ordinance 1990, the interpretation of Wild Life Officers includes Honorary Wild Life Rangers and their key role was to enforce the provisions of the ordinance. Thus in the early days HWLRs were also legally considered to be enforcement officers. However, an evaluation survey carried out 2000 to assess the effectiveness of the program prompted a formulation of a new concept where HWLR is about "volunteering, awareness and the love for nature" (Ahmad et al. 2008).

HWLRs are members of the public, who are over 18 years of age elected from headmen of villages, for instance *Tuai Rumahs* or *Penghulus*. These villages are usually within the vicinity of key areas or protected areas and HWLRs represent their communities in conservation issues. They function as 'eyes and ears' specific to their regions pertaining to issues on poaching, encroachment and so forth. Participation is on a voluntary basis and the members motivate others by working outside their regions. Members are also motivated to improve their knowledge on biodiversity conservation, thus this is an avenue for participative management. In short, HWLRs are "ambassadors" of conservation to help cascade the message of conservation to others.

c) Junior Wildlife Rangers (JWR)
Junior Wildlife Rangers is a conservation education programme where members of the public who are less than 18 years of age are invited to participate. Activities are drawn up for those who have enrolled, aimed at changing of attitudes and to instil love for nature. Programmes conducted in schools include Nature & U, Adventure with Wildlife, Friends of Nature.

(viii) Sarawak Hornbill Workshop 2012
Sarawak has been engaging communities in tourism and also biodiversity conservation programmes (participatory approaches or community based programmes). Eight resolutions have been drawn up from the Sarawak Hornbill Workshop 2012:

1. To establish the Hornbill Foundation Fund.
2. To step up research and development work on hornbills with a view to establish a central database that can be readily accessed for enhanced action for hornbill conservation in Sarawak.
3. To promote the conservation of hornbills through Communication, Education and Public Awareness (CEPA).
4. To enhance capacity building in areas of research, husbandry, protection, CEPA, interpretation and tourism.
5. To develop and promote hornbill-based tourism particularly involving rural communities in the Community-based Ecotourism (CBET) sector.
6. To identify and protect high conservation areas for hornbills outside TPAs, working at all levels of societies to protect and enhance the population of hornbills such as in Piasau Camp and wildlife corridors.
7. To develop a Strategic Management Plan for hornbills in Sarawak.
8. To bid for the opportunity to host the International Hornbill Conference in 2017.

CONCLUSIONS

Sarawak is enthusiastic about living up to the tag of "Land of the Hornbills" and serious efforts are undertaken for the conservation of hornbills in the State, whilst gearing up for the next International Hornbill Conference (IHC) in 2017. The State government has taken steps to implement recommendations from the previous Hornbill Workshop, which is for Sarawak to host the upcoming International Hornbill Conference in 2017, by sending representatives to attend the IHC in Manila to bid for the 2017 IHC.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Sarawak Convention Bureau for providing for our travel to Manila to present this paper and thus bid for the upcoming IHC in 2017.

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Table 1. Hornbill species in Totally Protected Areas of Sarawak.

Site	Mulu NP	Niah NP	Lambir NP	Similajau NP	Gunung Gading NP	Kubah NP	Batang Ai NP	Loagan Bunut NP	Tanjung Datu NP	Maludam NP	Santubong NP	Gunung Buda NP	Pulong Tau NP	Samunsam WS	Lanjak Entimau WS	Sibuti WS
Area (ha)	52,865	3,138	6,949	7,064	4,106	2,230	24,040	10,736	1,379	43,147	1,140	6,235	63,700	22,801	168,758	678
Species																
White-crowned Hornbill	+		+	+									+	+	+	
Bushy-crested Hornbill	+			+		+	+		+	+			+	+	+	
Wrinkled Hornbill	+	+		+										+	+	
Wreathed Hornbill	+		+			+	+		+				+	+	+	
Black Hornbill	+	+	+	+		+	+	+	+	+			+	+	+	+
Oriental Pied Hornbill	+	+	+	+	+			+	+				+	+		+
Rhinoceros Hornbill	+		+	+	+		+		+	+	+		+	+	+	
Helmeted Hornbill	+						+	+	+			+	+	+	+	

(Abbreviations: NP = National Parks; WS = Wildlife Sanctuary)

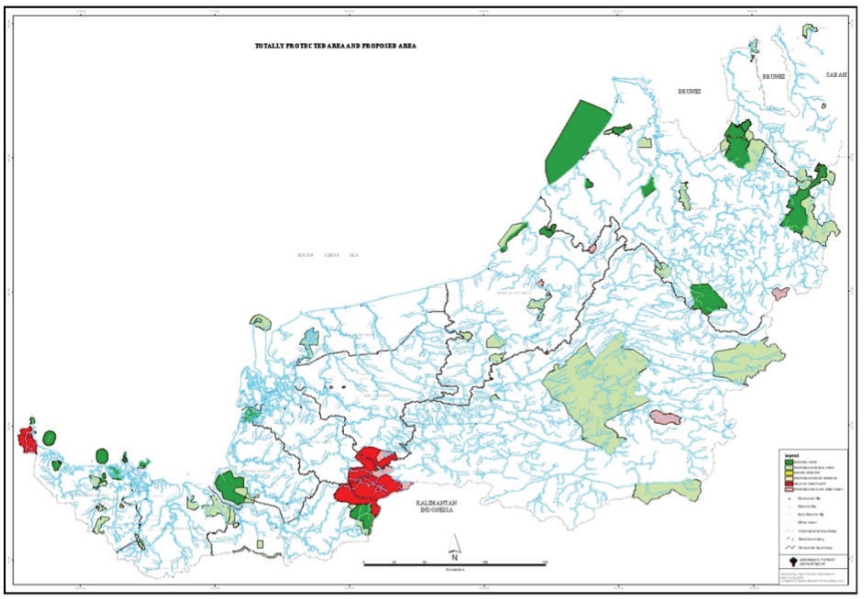

Figure 1. Map of Totally Protected Areas (TPAs) in Sarawak. (Source: Forest Department Sarawak)

Studies on the status, distribution, habitat ecology and strategic planning for conservation of Malabar Pied Hornbill *Anthrococeros coronatus* Central India

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Abstract: The Malabar Pied Hornbill *Anthracoceros coronatus* is one of 10 species of hornbills found in the Indian subcontinent. According to BirdLife International (2015), this species is listed as Near Threatened (Criterion NT C1) due to decreasing trends in its population because of poaching, deforestation and habitat loss and fragmentation. *A. coronatus* prefers deciduous forest and thick canopies with distinct distributional ranges i.e. Western Ghats, Eastern Ghats and some pockets of Satpuda of Central India. Vidarbha is the eastern region of Maharastra state, lies on the northern part of the Deccan Plateau and is adjacent to the Satpuda Hill ranges. Pench Tiger Reserve (PTR-MS), Tadoba-Andheri Tiger Reserve (TATR) and Melghat Tiger Reserve (MTR), plus two proposed tiger reserves and a number of sanctuaries, are located in the Vidarbha region. Vidarbha region supports two broad categories of vegetation, i.e., tropical semi-evergreen and dry deciduous with riverine patches. In PTR-MS, *A. coronatus* was recorded much earlier (Anon. 2000), but in TATR it was first reported in 2001 and in MTR in 2003. Until 2012, not much was known about the distribution, population, food preferences and breeding biology of *A. coronatus* in Vidarbha. A study was conducted to understand the status, distribution and threats to *A. coronatus* in the three tiger reserves of Vidarbha, viz. MTR, TATR, PTR and the contiguous Pench Tiger Reserve in Madhya Pradesh state (PTR-MP) and also some corridors between these protected forests. The present paper presents the findings of the study and focuses on the strategic planning for its conservation. A good population of *A. coronatus* was recorded in PTR-MS and PTR-MP compared to MTR, and the population was lowest in TATR. Seasonal food preferences were also studied with respect to the fruiting phenology of the fruit-bearing trees. Major threats to *A. coronatus* in the study area were found to be illegal tree felling, land encroachments and forest fires. This study also provides

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basic data to the Maharashtra State Forest Department that will help in preparing the management plan for the conservation of *A. coronatus*.

Keywords: Malabar Pied Hornbill, Vidarbha, Central India, Melghat, Pench, Tadoba.

INTRODUCTION

The Malabar Pied Hornbill *Anthracoceros coronatus* is a bird from the eastern Himalayas but now it is a resident species of the wet zone of the Western Ghats (Ali and Ripley 1987) of southern India. It is a resident species in the peninsular hills, from southwest West Bengal and Bihar to North Andhra, the Western Ghats (mainly along the eastern edge), south of South Maharashtra (Ratnagiri) and Sri Lanka (Rasmussen and Anderton 2005). It is a Near Threatened species (Criterion NT C1; BirdLife International 2015) and its population is declining. According to Pande et al. (2003), it is a resident of the Konkan, Malabar and the Western Ghats up to an elevation of 1,000 m asl.

Several hypotheses have been put forward to explain the dispersal of source species from the eastern Himalayas to the Western Ghats. The Satpuda hypothesis (Ali 1949; Hora 1949) envisages the Vindhya-Satpuda range in Central India as a "corridor" for the dispersal of taxa from the Eastern Himalayas to the northern end of the Western Ghats (Shrinivasan and Prashanth 2006). Hora (1949) postulated that the wet-zone species colonized southern India by way of a once continuous corridor of tropical evergreen forests from the eastern Himalayas across the Vindhya-Satpuda range to the Western Ghats of South India (Karanth 2003).

A. coronatus has already been reported from different places of the Satpuda range, including the Satpuda National Park, Pench Tiger Reserve, Madhya Pradesh (Pasha 1997) (PTR-MP), Satpuda Tiger Reserve in Madhya Pradesh (Koeltz 1946), also in Eastern Madhya Pradesh (Jayapal et al. 2005), the Tadoba-Andhari Tiger Reserve in 2001 (Anon. 2009), and the MTR where it was first reported in 2003 (Kasambe and Wadatkar 2006). MTR is an important forest area in the central part of the Satpudas in Maharashtra (MH). Presumably due to defragmentation of this corridor, *A. coronatus* was not reported from MTR until 2003. But after proper protection measures were provided to the forest corridors and the MTR region, habitat for *A. coronatus* became suitable again. A few birds might have migrated from the Satpuda Tiger Reserves in Madhya Pradesh or PTR-MP in search of a suitable habitat. As per the sighting records of *A. coronatus* in MTR from 2003 to 2008, it is clear that the bird has become well established in this area (Wagh et al. 2011).

Though this species was regularly spotted by bird watchers,

forest officers and locals in the study area, actual status, distribution, habitat, food preferences, roosting sites, nesting sites and threats of *A. coronatus* were not known, even though such basic data is essential for the conservation of *A. coronatus* and its habitat. So with these 'key thoughts' the authors and their team started the present study on *A. coronatus*.

In this study, the current status of the *A. coronatus* was evaluated in the three selected tiger reserves of Vidarbha (MS) and Pench Tiger Reserve in MP (PTR-MP). Abundance of *A. coronatus* was studied in relation to its habitat, food preferences, roosting and nesting sites.

The study also aims to develop local awareness about the species and train local forest department staff in monitoring and providing better protective measures. The present paper focuses on the status, distribution, ecology and strategic planning for conservation of *A. coronatus* in Vidarbha region, Central India.

MATERIALS AND METHODS

To understand the status and distribution of *A. coronatus* in MTR, and PTR-MS, PTR-MP and TATR more than 13 visits were undertaken from January 2010 to March 2013 to various parts of the study area, covering all major habitat types and all seasons of the year (breeding and non-breeding seasons). Also, we conducted several interviews with locals, tribes, forest staff and bird watchers from time to time to obtain information about the present status of the *A. coronatus* by showing them the pictures, making them listen to the recorded bird calls and sometimes by showing actual birds in the wild.

Point transects were primarily conducted to monitor population of *A. coronatus* in evergreen and riverine forests of the tiger reserves. During field visits in the non-breeding season, the observers walked the points and encountered the hornbills.

Data of fruit-bearing plants used by Malabar Pied Hornbill for foraging in MTR, PTR-MS and TATR was collected. Observations were taken with telescope (15 x 60 Nikon) and binoculars (10 x 50 Nikon) and photographs were taken using a Nikon D90, D5000 Camera with 70-300 mm and 80-400 mm, zoom lenses. Locations of sightings of the species were recorded using a Garmin GPS unit.

Available literature related to the species was referenced, compiled and analyzed. Data on sightings of *A. coronatus* in Vidarbha were collected.

Study area

In Central India, Vidarbha is the eastern region of the Maharashtra. Madhya Pradesh (MP) lies on the northern part of the Deccan Plateau and is adjacent to the Satpuda Hill ranges. PTR, TATR and MTR, along

with the two proposed tiger reserves and number of sanctuaries, are located in Vidarbha.

Forests in Vidarbha occupy about 31.60% of the total area of Maharashtra state forest. The forest types found in the area are classified as Sub-tropical Hill Forest, Tropical Moist Deciduous Forest and Lush Green Deciduous Forest (Champian and Seth 1968).

Vidarbha has three main seasons, a wet monsoon and post-monsoon from June to September, cool dry winter from October to February and the hot dry season from March until the onset of the rains. Temperature of Vidarbha ranges from a minimum of 12 - 25^{o}C to a maximum of 30-48^{o}C, with the relative humidity varying from 10 - 15% to 60 - 95%. Annual precipitation is 1,700 mm and about 90% of the precipitation is in the four months from June to September.

The Indian subcontinent hosts about 1,295 bird species (Grimmett et al. 2009), of which more than 550 species have been reported from Maharashtra State. In Vidarbha, a total of 417 bird species has been reported (Anon. 2009).

Two hornbill species are found in all the Tiger Reserves in the study area, viz., Malabar Pied Hornbill *A. coronatus* and the Indian Grey Hornbill *Ocycerous birostris:* both are endemic to the Indian subcontinent. Of these, *A. coronatus* has been recorded only from the protected areas while the Indian Grey Hornbill has been recorded in both the protected and non-protected forest areas. The latter species is also found in the agricultural and urban areas of Vidarbha. However in this study we documented the status, distribution and habitat of only *A. coronatus*, due to their minimal abundance as compared to Indian Grey Hornbill in the four Tiger Reserves, three of Vidarbha (MS) and the forth in MP (Figure 1).

Melghat Tiger Reserve (MTR)

MTR (20^{o} 51' - 21^{o} 46' N 76^{o} 38' - 77^{o} 33' E) is located in the Maharashtra state of India. The MTR is a part of the Satpuda Range of hills in Central India and is spread over an area of 3,970 km^2 in the Amravati and Akola districts of Maharashtra. Out of this, 2,100 km^2 area is protected under MTR, which includes five protected areas under unified control namely, Gugamal National Park, Melghat Sanctuary (the buffer zone), Narnala Wildlife Sanctuary, Wan Wildlife Sanctuary and Ambabarwa Wildlife Sanctuary (Figure 1A). MTR has the Southern Tropical Dry Deciduous type of forest but in some parts the forest is semi-evergreen, starting from the west side of Chikhaldara and spreading up to Kolkhas, Kund, Koha and the Koktoo area. Sipna and Dolar are the major rivers flowing through MTR, providing riverine habitat for *A. coronatus*. MTR experiences a tropical climate, with temperatures ranging between 13oC and 22oC during winter and between 23^{o}C and 45^{o}C during summer. The annual rainfall ranges between 1,000 mm and 2,250 mm.

Pench Tiger Reserve, Maharashtra (PTR-MS) and Madhya Pradesh PTR (MP)

Both parts of Pench Tiger Reserve in Madhya Pradesh and in Maharashtra derive their name from the Pench River, which meanders along their central lines. PTR-MS is situated along the northern boundary of Nagpur district, adjoining Seoni and Chindwara districts of Madhya Pradesh. PTR-MS lies between 21° 40' 15" to 21° 43' 10" N and 79° 04' 10" to 79° 24' 50" E. It is located in the southern lower ridges of the Satpuda hill ranges, which form the catchment area of the Pench River. The total area of the PTR-MS core is about 257.26 km^2 and the buffer zone is 483.96 km^2. The forest type of the PTR-MS is Tropical Dry Deciduous (Figure 1B).

PTR-MP is situated in the districts of Seoni and Chindwara of Madhya Pradesh close to the border of PTR-MS. This Tiger Reserve covers an area of 757.920 km^2 and lies between 21° 38' to 21° 50' 30" N and 79° 09' to 79° 22' 03" E. The forest is Tropical Dry Deciduous and Semi-evergreen (Figure 1C).

Tadoba-Andhari Tiger Reserve (TATR)

TATR covers an area of about 625.40 km^2 in Chandrapur district of Maharashtra state. The habitat in TATR consists of Southern Tropical Dry Deciduous Forest interspersed with several large meadows. The forest is dominated by Teak *Tectona grandis* and bamboo *Dendrocalamus strictus* and lies between 21° 23' 23" N and 79° 26' 05" E. (Figure 1D). The reserve gets its name from Andheri River, which flows through the reserve and finally joins the Wainganga River.

RESULTS AND DISCUSSION

The present study found *A. coronatus* in the four Tiger Reserves i.e. MTR, PTR-MS, PTR-MP and TATR in Central India, and identified its prime habitats, food preferences and threats. It was observed that the dry deciduous forest was used for foraging, and the riverine forest was used for foraging and nesting.

A. coronatus was first reported in MTR in 2003 (Wagh et al. 2011) but now its presence is well established in this area. As per the sightings given in Table 1, *A. coronatus* was found almost throughout the year in the study area and this indicates that *A. coronatus* is not a passage migrant or vagrant to MTR. Out of the nine sightings from MTR, three sightings were reported from the core area and six sightings from the Melghat Sanctuary part of the MTR that covers approximately 50% of the MTR. Though most part of MTR has the Southern Tropical Dry Deciduous type of forest, some parts of the forest are semi-evergreen, starting from the western side of Chikhaldara hill-station and spreading

up to Kolkaj, Kund, Koha, Koktu, and Gularghat. Canopies of large ancient fig trees, like *Ficus benghalensis* and other *Ficus* species are also available in many of parts of this area.

A. coronatus was reported much earlier in PTR-MS, but during our surveys we recorded a total of 12 individuals at four different sites, i.e. Ambakhori, Totladoh, Kantra-Utar Nala and Sillari Gate (Table 2). Maximum numbers were sighted at Ambakhori when they were calling. PTR-MS forest is of the semi-evergreen and dry deciduous types, with Teak and Salai *Shorea robusta* dominanting the habitat with dense canopy, and excellent meadows. Fruiting plant species like *Ficus* are the dominant in this area. The Pench River passes through the midline of PTR-MS, creating many evergreen riverine patches along its edges and these patches act as the potential sites for the roosting and nesting of *A. coronatus*. *A. coronatus* prefers figs as food in PTR-MS but sometimes they were also found feeding on small mammals like squirrels and bats. Two nesting sites were also recorded, at Ranidoh and Sillari Gate in PTR-MS.

PTR-MP and PTR-MS are contiguous forest areas, but divided administratively into two different states. During our survey as per the sightings and reports of the local forest department staff, a total of 13 individuals of *A. coronatus* were recorded at Karmajhari, Raiyakasa, Boda Nala and Turia Gate in the PTR (MP) (Table 3). Most of the forest type in PTR-MP is similar to PTR-MS but *Ficus* species and Kusum trees *Schleichera oleosa* are dominant here. Three nests were reported, at Raiyakasa, Sitaghati and Boda-Nala areas in PTR-MP.

TATR is one of the best managed Tiger Reserves in Maharashtra State. *A. coronatus* was reported for the first time in TATR in 2001 at Mohurli gate area and, during our surveys, we recorded only five individuals of *A. coronatus* in TATR at Mohurli, Kolsa, Jamani and Navegaon (Table 4), and of these four sites, Mohurli is a regular roosting site for *A. coronatus*. No nest was found in TATR during the study period.

Food preference

A. coronatus are both fruit and flesh-eaters. They are far-ranging in their search for food and drop the seeds of the fruits they eat as they go, dispersing them over a wide area. They are thus important seed dispersers for the forest, acting as an agent of forest regeneration, at the same time controlling large-sized insects and other small animals. As such, they can be regarded as indicators of high moist forest, ensuring the continuance of forest health and species richness (Balasubramanian et al. 2004).

For food preferences and feeding habits, *A. coronatus* was studied in different seasons in the four Tiger Reserves of the study area by walking along transect lines or by direct searches during our field visits, and observations about the foraging habits were noted down (Table 5). In MTR, *A. coronatus* was seen foraging on the fruits of 10 fruit-plant

species namely, *F. benghalensis, F. religiosa, F. racemosa, F. infectoria, F. virega, Syzygium cumini, Adina cordifolia, Schleichera oleosa, Phoenix sylvestris* and *Grewia tiliifolia.*

Ficus species fruits were found as a major food source of *A. coronatus* in MTR. Regarding the food preference of *A. coronatus* in MTR, it was noted that during summer, *A. coronatus* dispersed towards the hilly region of a famous hill-station in Vidarbha, Chikhaldara, and preferred the fruits of *Ficus* species *i.e. F. benghalensis, F. religiosa, F. racemosa* and two non-*Ficus* species *i.e. P. sylvestris* and *S. cumini*. The relatively open riverine habitats on the banks of the River Sipna also provide important roosting site for *A. coronatus* in MTR.

During food preference studies in the non-breeding and breeding period in both PTR-MS and PTR-MP, *A. coronatus* were observed to feed on fruits of *S. cumini, F. benghalensis, F. religiosa, F. racemosa, F. infectoria, Adina cordifolia, Schleichera oleosa*, and *G. tiliifolia*.

A. coronatus was seen feeding on small mammals like Three-striped Palm Squirrel *Funambulus palmarium* and Short-nosed Fruit-eating Bat *Cynopterus sphinx* during the breeding season (K. Thomare pers. comm.).

TATR is composed of mixed forest types, with bamboo and Teak as the dominant vegetation. *Ficus* species are uncommon and hence *A. coronatus* preferred the fruits of *F. benghalensis, F. religiosa, F. racemosa, Adina cordifolia, S. cumini* and *Zizyphus mauritiana*.

Riverine evergreen habitats in MTR, PTR-MS and PTR-MP provide important roosting sites for *A. coronatus*. They mainly roosted in the foliage of tree species like *Terminalia arjuna* and *A. cordifolia*.

In the four selected Tiger Reserves of Central India, a total of 54 individuals of *A. coronatus* were reported, 27 from MTR, 12 from PTR-MS, 10 from PTR-MP and five from TATR (Tables 1-4). The maximum number was found in MTR and lowest in TATR, but since MTR covers about 50% of the total study area, PTR-MS covers 18%, PTR-MP covers 18% and TATR covers 15%.

In MTR *A. coronatus* was found almost throughout the year in the study area. This indicates that it is not a passage migrant or vagrant to the study area. Most of the sightings from MTR were reported from the central part of the Reserve, i.e. Gularghat, Dharghad, Koktu, Dhakana, Kund, Bander Kahu, Kolkhas, Chourakund and Raipur, and these areas covered approximately 50% of the MTR. Crowns of large old trees like *Ficus* species were seen in most of the area.

We also noted *A. coronatus* in and around Chikhaldara in the month of April, May and June, where there are several ancient *F. benghalensis* and *P. sylvestris* trees around Chikhaldara, the famous hill-station in Vidarbha. April to June is the fruiting period of *F. benghalensis* and *P. sylvestris* in Chikhaldara region and hence most of the time the hornbills were found to be feeding on these fruits.

Presence of juveniles with adults confirms their breeding status in this region, although only a single nest hole was located in MTR. The lack of nesting record from MTR could be due to of the difficulty in locating nests, which could in turn be due to the vastness of the area and hilly terrain.

CONCLUSIONS

As per the observations, abundance of *A. coronatus* is much lower in all the Tiger Reserves of the study area as compared to the Western Ghats, and even their sightings are scarce.

From the above data, we assume that the abundance of *A. coronatus* could be dependent on the type of vegetation, availability of riverine habitat, temperature, availability of food and size of the area.

During the survey, most of the sightings were recorded from Protected Areas (core and buffer zones) and no sightings were recorded from the corridors in between these Tiger Reserves.

This could be due to degraded habitat, low number of old plants, low *Ficus* species dominance, discontinuous forest patches, heavy anthropogenic pressure and/or failure in nesting.

No poaching or illegal hunting of hornbills by locals or tribes was observed during the survey in all the Tiger Reserves of the study area. There are reports of *A. coronatus* being hunted by tribals in Dandeli forest of Western Ghats for medicinal purpose (Vijaykumar et al. 2011).

No natural predators of the *A. coronatus* have been observed during the study period. Clear felling by locals in buffer zones for agriculture expansion, intentional forest fires and old trees falling due to heavy rain and storms were recorded to be the major threats to the habitat of *A. coronatus*.

This study also provides the basic data to the Maharashtra State Forest Department, which will help to prepare the management plan for the conservation of *A. coronatus*.

ACKNOWLEDGEMENTS

We thank the University Grants Commission, New Delhi, for the financial support for a minor research project to the first author (GW). The authors wish to thank, Dr. V. G. Thakare, Principal and Dr. C. B. Meshram, for their constant support and encouragement. Thanks are also due to our field colleagues, Mr. Nandkishor Dudhe, Mr. Alkesh Thakare, Mr. Manish Dhakulkar, Mr. Gaurav Kadu and Mr. Suraj Pawar for accompanying us during the field trips to the study area. Thanks to PCCF (Wildlife), Department of Forests, Nagpur, Govt. of Maharashtra

for giving permission and for partially supporting the visits to protected areas in Maharashtra. Thanks to PCCF (Wildlife), Department of Forests, Madhya Pradesh for giving similar permission. Thanks to the anonymous reviewer for the comments which helped in improving the manuscript.

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Table 1. Sightings of Malabar Pied Hornbills *A. coronatus* in Melghat Tiger Reserve.

SN	Area	Location	Altitude (m asl)	No. of birds
1	Kolkaj	21° 29' 49" N 77° 12' 30" E	422	3
2	Bujrukpadaw	21° 32' 52" N 77° 14' 12" E	463	4
3	Semadoh	21° 34' 52" N 77° 16' 12" E	538	2
4	Raipur	21° 34' 52" N 77° 16' 12" E	538	2
5	Chourakund	21° 32' 45" N 77° 06' 39" E	385	1
6	Banderkahu	21° 27' 21" N 77° 16' 14" E	550	2
7	Chikhaldara	21° 21' 42" N 77° 22' 26" E	1,067	7
8	Koktu	21° 19' 14" N 77° 02' 42" E	531	4
9	Gularghat	21° 15' 31" N 77° 00' 52" E	585	2

Table 2. Sightings of Malabar Pied Hornbill *A. coronatus* in Pench Tiger Reserve, Maharastra state (PTR-MS).

SN	Area	Location	Altitude (m asl)	No. of birds
1	Ambakhori	21° 41' 10" N 79° 40' 10" E	190	6
2	Tataladoh	21° 42' 15" N 79° 30' 20" E	179	2
3	Kantra-utar Nala	21° 41' 10" N 79° 28' 40" E	184	2
4	Sillari Gate	21° 43' 15" N 79° 24' 50" E	193	2

Table 3. Sightings of Malabar Pied Hornbill *A. coronatus* in Pench Tiger Reserve, Madhya Pradesh state (PTR-MP).

SN	Area	Location	Altitude (m asl)	No. of birds
1	Karmajhari	21° 49' 39" N 79° 18' 89" E	494	2
2	Raiyakasa	21° 48' 50" N 79° 17' 67" E	476	3
3	Boda Nala	21° 45' 98" N 79° 19' 34" E	500	2
4	Turia Gate	21° 43' 47" N 79° 16' 16" E	464	3

Table 4. Sightings of Malabar Pied Hornbill *A. coronatus* in Tadoba-Andheri Tiger Reserve (TATR).

SN	Area	Location	Altitude (m asl)	No. of birds
1	Mohurli	21° 23.23" N 79° 26.05" E	238	2
2	Kolsa	21° 23.23" N 79° 26.05" E	245	1
3	Jamani	21° 23.23" N 79° 26.05" E	224	1
4	Navegaon	21° 23.23" N 79° 26.05" E	256	1

Table 5. Food preference of the Malabar Pied Hornbill *A. coronatus* in the study area.

SN	Plant species	MTR	PTR-MS	PTR-MP	TATR
1	*Ficus benghalensis*	√	√	√	√
2	*Ficus religiosa*	√	√	√	√
3	*Ficus racemosa*	√	√	√	√
4	*Ficus infectoria*	√	√	√	-
5	*Ficus virens*	√	√	√	√
6	*Syzygium cumini*	√	√	√	√
7	*Adina cordifolia*	√	√	√	√
8	*Schleichera oleosa*	√	√	√	-
9	*Grewia tiliifolia*	√	√	√	-
10	*Phoenix sylvestris*	√	-	-	-
11	*Zizyphus mauritiana*	-	-	-	√

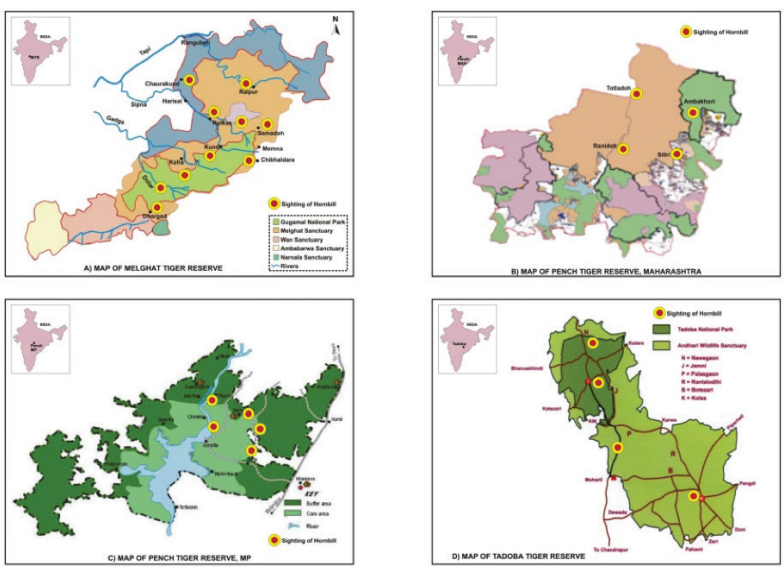

Figure 1. Map of Tiger Reserves in Central India.
[(A) Melghat Tiger Reserve (MTR), (B) Pench Tiger Reserve, Maharashtra state (PTR-MS), (C) Pench Tiger Reserve, Madhya Pradesh state (PTR-MP), (D) Tadoba-Andheri Tiger Reserve (TATR)]

The breeding biology of the Great Hornbill *Buceros bicornis*, Rhinoceros Hornbill *Buceros rhinoceros* and Helmeted Hornbill *Rhinoplax vigil* in the Temengor Forest Reserve, Perak, Malaysia

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Abstract: Three species of hornbills in Temengor Forest Reserve, Perak, Malaysia was observed during their breeding period from January 2009 to September 2009. There is a lack of information on the breeding biology in the wild, thus the nesting and feeding behaviour of the Great Hornbill *Buceros bicornis*, two pairs of the Rhinoceros Hornbills *Buceros rhinoceros* and one pair of Helmeted Hornbill *Rhinoplax vigil* (n = 4) were observed. The female Great Hornbill spent 56-87 days inside the cavity. The fruits fed on by the Great Hornbill originated from families; Annonaceae, Elaeagnaceae, Moraceae, Sapotaceae. However, their breeding attempts failed during this study. Both the female Rhinoceros Hornbills from two different nest cavities successfully raised one chick each and the females spent 82-111 days and 50-79 days in the nest cavity, respectively. The fruits consumed by the two pairs of Rhinoceros Hornbill originated from families; Annonaceae, Arecaceae, Cornaceae, Elaeagnaceae, Moraceae, Meliaceae, Myristicaceae and Sterculiaceae. One of the Rhinoceros Hornbill pairs chose to nest in a tree identified as *Koompassia malaccensis* Maing. ex Benth. (family: Leguminosae). The female of the Helmeted Hornbill spent 140-162 days inside the cavity. The male brought mainly non-fig fruits to the inmates. The pair successfully raised one chick and their nest tree had been identified as *Dysoxylum grande* Hiern (family: Meliaceae). In addition, a Wreathed Hornbill nest tree was identified as *Terminalia bellirica*, though it was inactive during this study period.

Keywords: hornbill, Great Hornbill, Rhinoceros Hornbill, Helmeted Hornbill, hornbill breeding behaviour, Temengor, nest cavity, hole nesters, hornbill preferred fruits

INTRODUCTION

There are 10 species of hornbills in the Belum-Temengor Forest Complex in Perak, Malaysia and we made additional studies on the breeding biology of three hornbill species in Malaysia. Generally for

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Asian hornbills, upon mating, the female will seal itself inside the cavity, leaving a narrow slit for which the male will use to pass food material to the female. Nest sanitation is observed, as both chick and female will squirt out faeces through the narrow slit of the cavity (Poonswad and Kemp 1993).

The breeding behaviour of the Helmeted Hornbills is poorly studied (Kemp 1995; del Hoyo et al. 2001). Preferring a knob shaped nest cavity (Chong 2011; Davison et al. 1995; Thiensongrusamee et al. 2005), the Helmeted Hornbill nests primarily in *Hopea* sp. and *Shorea faguetiana*. The height of the nest tree ranges from 26-70 m while the diameter at breast height (dbh) of the nest tree ranges from 105-216.6 cm. These nest trees were found growing at altitudes ranging from 300 - 535 m asl, usually on slopes (Thiensongrusamee et al. 2005). Both the Helmeted *Rhinoplax vigil* and the Red-knobbed Hornbills *Aceros cassidix* have been documented as the longest imprisonment, which can last between 167 - 172 days (Kinnaird and O'Brien 2007).

The first nesting record in Malaysia of a pair of nesting Helmeted Hornbills lacked information on breeding (Wells 1999). Although the second nesting record had been observed and described in more depth by (Chong 2011), the nest was located in a sub-montane region in Genting Highlands, Malaysia, unlike this study, which involved a lowland type forest. Described as the 'hollowed stump of a broken branch', the cavity was located 30 m from the ground, at an 800 m asl on a steep slope. The sealing process, carried out entirely by the female, took 13 - 14 days to be completed. The estimated period of the incarceration of the female is between 154 - 167 days. Chong (2011) did not address feeding and nest tree species preferences. Therefore, in the proposed study, more observation time had been allocated for the Helmeted Hornbill to address the knowledge gaps.

Several studies have been conducted on captive Rhinoceros Hornbill *Buceros rhinoceros*, such as Reilly (1988), Strehlow (2001), and Urban et al. (1999). In Malaysia, wild-nesting Rhinoceros Hornbills have been reported to nest in *Shorea paucifolia* tree (Johns 1982). Research in Sumatra by WCS Indonesia Program revealed that the nesting cycle of Rhinoceros Hornbill may last as long as 115 - 143 days. Their incubation period lasts 37 - 46 days, and the nestling period 78 - 82 days. As for the female, it stayed within the cavity for 86 - 97 days and leaves the nest cavity before the chick fledges. In addition, the nest trees have been documented to have a dbh of 111.6 cm with the height of the nest at 31 m (Kinnaird and O'Brien 2007).

The breeding behaviour of captive Great Hornbills *Buceros bicornis* have been studied by Choy (1980), Nehls (2000), Poulsen (1970) and Golding and Williams (1986). Their nesting cycle in the wild lasts up to 140 days with 1 - 4 days for pre-laying, an incubation period of 40 days, and 72 - 96 days for the nestling period (Poonswad and Kemp

1993). The male makes three trips in a day to the nest cavity to provide food, spending 15 - 20 minutes per day to feed (Ali et al. 1970). The height of the nest from the ground ranged from 10.5 – 30 m with a 54 – 157 cm dbh. Nest trees were found at altitudes ranging from 700 - 850 m asl (Poonswad and Kemp 1993).

Great Hornbills have the tendency to utilize a nest cavity with an elongated entrance (Thiensongrusamee et al. 2005). Both the female and male use their faeces and food materials to seal the entrance. The sealing is then placed by a sideways tapping of the bill, to the sides of the nest hole (Golding and Williams 1986). Great Hornbills do not use mud as sealing material (Golding and Williams 1986; James et al. 2007). Among the 27 nest trees utilized by Great Hornbills in Thailand, 11 nest sites were *Dipterocarpus* trees and seven were *Syzygium* trees. The others belonged to the genera *Altingia, Lithocarpus, Cinnamomum, Tetrameles,* and *Shorea*. (Poonswad and Kemp 1993). In Arunachal Pradesh, Great Hornbills, Wreathed Hornbills and Oriental Pied Hornbills have been reported to use *Tetrameles nudi lora* as their nesting tree, a deciduous tree found in lowlands (Datta et al. 2004).

In addition, the nesting behaviour in Malaysia of Bushy-crested Hornbill *Annorhinus galeritus* was described by Madge (1969) and Styring et al. (2002), while the nesting behaviour of Oriental Pied Hornbill *Anthracoceros albirostris*, of the southern race *convexus*, was described by Pan (1987). Thus, this study brings forth new knowledge concerning the hornbills in Malaysia for further comparisons.

MATERIALS AND METHODS

Study area

Located in the north of Peninsular Malaysia, the Temengor Forest Reserve covers 148,870 ha. The forest is mainly hill dipterocarp forest (e.g. mainly *Dipterocarpus* and *Shorea* tree spp.) and the hilly and mountainous regions within this area are part of the central forest spine. The Temengor Lake (152 km^2) came into existence in 1978, for the purposes of hydroelectric power generation (Davison et al. 1995).

Methods and materials

A cash reward was offered to the locals for the discovery of active nest trees. Observations began in January to September 2009 and two weeks were then allocated to the discovered nest trees for each month. The observation methods were based on Poonswad and Kemp (1993). Full day observations (> 500 minutes) were conducted from dusk to dawn, as permitted by sunlight (0700 - 1900 hours). All data was recorded on a standardized survey sheet. A temporary hide was constructed to keep

the observers out of view during the nest observations. To document food preferences, a large plastic sheet (1.5 m x 1.5 m) was placed under the nest cavity, almost touching the nest tree. The fallen debris were examined and collected after every feed, in the absence of the male. The food materials were categorized as fig, non-fig and animal matter. Binoculars (Bushnell 8 x 42 Field 6.0º 105 m / 1000 m) and a spotting scope (Leica APO – TELEVID 77, T77: 20x–60x, T62: 16x–48x) were used to observe the hornbill's behaviour. In addition, the use of a video camera (Panasonic AVCCAM HD 3CCD) and digital cameras (Olympus E3) aided in the documentation process.

RESULTS

The trees with hornbill nest cavities were measured to record their height, circumference and cavity height. Additional information such as tree condition and its species were provided whenever possible (Table 1).

Breeding behaviour of Great Hornbill

During the nest sealing activity, the Great Hornbill female used new sealing material in the absence of the male. The male did not engage in this activity. In one day, the longest time spent by the female for sealing activities was 330 minutes. It was seen sealing the nest cavity over a span of 23 days.

In the incubation phase, on a one-time occasion, the female regurgitated almost half the quantity of fruits it had received from the male and allowed it to fall to the ground. The male hornbill did not engage in any nest cleaning activities. To exit the nest, the female broke the sealing material, using its bill to chip away at the sealing material. This 12-minute struggle began by the female putting its whole head outside the cavity, followed by its left wing. During its exit, the male called softly. Upon releasing itself from the cavity, it flew to perch on a branch on the nest tree and began preening. The pair then joined in a duet call. There were no signs of any chick(s). The estimated nesting schedule of the Great Hornbill is depicted in Figure 1.

The number of nest visitation by the male increased during week one to week four. The visitations then decreased towards week nine, and subsequently had completely ceased after the female exited the nest cavity (Figure 2).

In the absence of the male hornbill, visits were made to the base of the nest tree, to retrieve fallen fruits and seeds accumulated in the netting sheet below the tree (Table 2). The most number of deliveries recorded in a day was three times, while the least number of food deliveries was two

times in a day. From 14 observed visits, the mean of minutes spent at the nest cavity was 3.07 (SD ± 2.40). The longest time spent at the nest cavity was eight minutes and the least number was one minute. 77.36% of the fruits delivered were non-figs and 22.64% consisted of fig fruits. As for animal matter, the female Great Hornbill consumed a giant millipede (Harpagophoridae) (*Thyropygus* sp.) and a gecko (Gekkonidae) (species unknown). The male did not deliver these items. Instead, they were captured at the nest entrance and consumed by the female hornbill.

Breeding behaviour of Rhinoceros Hornbill (RHB01-06)

Three feathers retrieved from the base of the nest tree suggested molting of the female's feathers. Nest sanitation was observed by both chick and female. They would turn around to face their cloaca at the nest entrance and eject faeces. After an hour of struggling, the chick emerged from the nest one morning by pecking and breaking the sealing material. At that time, the adults remained close within the area. The estimated nesting schedule of the Rhinoceros Hornbill (RHB01-06) is depicted in Figure 3. The most number of food deliveries in a day was six and the least number of deliveries in a day was two. From 11 observed visits, the mean of minutes spent at the nest cavity was 3.81 (SD ± 2.71). The longest time spent at the nest cavity was nine minutes and the least number was one minute. 45.87% of the food delivered was non-fig fruits followed by 43.89% of fig fruits and 9.90% of animal matter. The animals consumed by the hornbill were a scorpion (unknown species), a bird (unknown species), a rodent (unknown species) and a giant millipede Harpagophoridae (*Thyropygus* sp.)

Breeding behaviour of Rhinoceros Hornbill (RHB02-06)

Six feathers retrieved from the base of the nest tree suggested molting of the female's feathers. During a visit, the chick was seen engaged in nest resealing activities by itself. It patted the sealing material down with its well-developed bill and even added a feather. The estimated nesting schedule of the Rhinoceros Hornbill (RHB02-06) is depicted in Figure 4.

In the absence of the male hornbill, visits were made to the base of the nest tree, to retrieve fallen fruits and seeds accumulated in the netting sheet below the tree (Table 3).

Breeding behaviour of Helmeted Hornbill (HHB01-07)

The Helmeted Hornbill would perch on the stump-like nest cavity and regurgitate fruits one by one to feed. It would not hang onto the nest cavity, unlike the Great Hornbill and Rhinoceros Hornbill. On one occasion as it remained perched at the nest cavity, it called out *'kok'*

88 times and ended its call by bursting into a 'maniac laugh' call. The female responded with a similar call.

Fallen fruits lying around the nest cavity were re-offered to the inmates. The most number of fruits fed by the male Helmeted Hornbill in one feeding session was 168 small fig fruits, and the feeding activity took 35 minutes to complete. At times, the fruit became lodged inside the roof of its bill, causing the male to struggle to free it by shaking its bill, jerking its head backwards and rubbing each side of its bill around the nest cavity. During the nestling phase, unusual feeding behaviours were noted:

- 16 June 2009 - The nest area was being visited by a flock of Oriental Pied Hornbills. While feeding, the male swallowed a piece of fruit then hopped on to the nest tree and knocking sounds were heard.
- 25 June 2009 - A flock of Rhinoceros Hornbills were present within the nest tree area. The male returned to the nest cavity with a fruit. Then, it hopped up the tree and knocking sounds were heard. It returned to the nest cavity with fruit in bill. The sound of wings could be heard, and the male did not feed. Instead it hopped up the nest tree yet again. Minutes later, the male returned to feed with the same fruit again. It swallowed the fruit, then regurgitated it and hopped upwards on the nest tree. There were also Dusky Leaf-monkeys *Trachypithecus obscurus* present in the nest area.
- 22 July 2009 - The male fed 15 small fruits then hopped up the nest tree with fruit still in its bill. Half an hour after the feed, the male returned to feed fruits but then flew away yet again with fruit in its bill. At the same time, a White-crowned Hornbill *Berenicornis comatus* began calling and flying around the nest area.
- 23 July 2009 - The male flew to the cavity to feed, with a fruit seen in its bill but it stayed perched on the nest cavity and did not feed. It then hopped up the nest tree. There was a ruckus caused by a few dusky leaf monkeys in the canopy. The male flew away from the nest tree. Two hours after the last attempted feed, there were sounds of wings heard. The male flew to the nest cavity but did not land. It hovered (for a split second) and then flew back to a nearby tree. One minute later, the male flew to the cavity to feed.

The male ended feeding sessions by picking up faeces and food remains with its bill sideways and tossing them away. Cleaning practices were not continued after the departure of the female. Prior to the female's departure and late into the nestling phase, the male returned with fruit but did not feed. This behaviour was noted on several occasions as follows:

- 24 July 2009 - The male returned to feed 22 fig fruits but the 23rd fig was offered by the male several times but it was taken.

- 19 August 2009 - The male returned to feed 12 large dark, oval red figs. The 13th fruit was regurgitated yet swallowed back.
- 20 August 2009 - The whole head of the female could be seen. For 15 minutes, the male offered one fruit 12 times but the inmates did not take it. The male resumed feeding as usual.

On the day of the female's departure, its head was seen outside of the nest cavity. The male offered a fruit a few times, and then it merely stayed perched. The male called *'kok'* softly while the female continued breaking sealing material, flinging pieces of it out as it tried to struggle out of the cavity. The male called out, breaking into a 'maniac laugh' and the female responded with a similar call.

Knocking sounds were heard from inside the cavity when the female pulled its head back into the cavity. Then, the female broke out of the nest cavity swiftly. The male returned to feed with 22 fig fruits without hesitation. The male made soft calls when it fed the chick *'kok'*. The female did not participate in feeding activities for five days after its exit.

During the nestling phase, the male returned to feed and the first fruit was offered twice but not received by the chick. The last fruit though regurgitated was swallowed back by the male. The chick was heard calling out in a typical Helmeted Hornbill 'maniac laugh' call. As the days progressed, the chick placed more of its head outside the nest cavity. The female made her first visit, fed the chick and gave a long deep growl like call. It placed its head into the cavity several times before it hopped up the nest tree. On 31 August 2009, the chick began breaking the nest cavity sealing. The observers returned to the nest site on the 7 September 2009, and discovered the nest cavity was empty and that the chick had fledged. The estimated nesting schedule of the Helmeted Hornbill is depicted in Figure 5.

The Helmeted Hornbill male made up to seven food deliveries in a day. The least amount of food deliveries made in a day was two. From 33 observed visits, the mean of minutes spent at the nest cavity was 5.08 (SD ± 4.03). The most time spent at the nest cavity was 20 minutes and the least was half a minute. 57.59% of the food delivered was non-fig fruits, 39.97% were fig fruits and 2.44% of the food material was animal matter. Animal matter which was delivered consisted of several stick insects (unknown species), a snake (unknown species) and a centipede (unknown species). The mean number of nest visitation by the male increased from week six to week nineteen. The visitations then decreased towards week twenty-three (Figure 6).

DISCUSSION

Nesting cycle begins in the dry season (Poonswad et al. 1987; Kinnaird et al. 1999), when the conditions inside the cavity are most suitable (Poonswad 1993). In this study, the hornbills nested during a period of lower rainfall. Based on available rainfall data for certain months in 2009, the rainfall for January was measured less than 100 mm. February and June received less than 50 mm of rainfall. Rainfall increased in July, with rainfall up to 150 mm and 250 mm for August (Department of Irrigation and Drainage Malaysia 2009).

Nest tree characteristics

The nest cavity opening for Helmeted Hornbill differed from that of the Great and Rhinoceros Hornbills. It used a knob-like nest cavity. This unique behaviour has been attributed to its heavy head and the prevention of wear and tear of the tail feathers (Thiensongrusamee et al. 2005). In this study, the Helmeted Hornbill spent the most amount of time perched at the nest cavity perhaps due to its comfortable perch.

All three species of hornbills nested in live instead of dead trees. The conditions in a nest cavity may be at its optimum in living trees, largely due to the natural processes that take place such as photosynthesis and respiration (Poonswad 1993). It is unlikely that hornbills choose a specific tree species to nest inside. Hornbills would seek large, tall and common trees with suitable cavities to meet their nesting needs.

In Thailand, the Plain-pouched Hornbills nested in the most commonly found tree, *Tetrameles nudiflora*, a tree species favoured by large woodpeckers (Chimchome et al. 1998; Datta et al. 2003 in Kinnaird and O'Brien 2007). *T. nudiflora* has also been reported as the Sumba Hornbill's preferred nest trees (Marsden et al. 1997). The Great, Wreathed and Oriental Pied Hornbills preferred *T. nudiflora*, followed by *Ailanthus grandis*. Emergent trees were chosen based on height, cavity height, commonness and softness of its wood for easy cavity creation (Datta et al. 2004).

Nest sealing

The Great Hornbill female spent the longest time sealing the nest entrance. The sealing material contained fig seeds and it was applied to the nest entrance sides with a sideways tapping of the bill, similar to what had been observed in captive pairs (Poulsen 1970; Golding and Williams 1986). There were also large intervals between the male's visit and the appearance of new sealing material, suggesting that the materials were obtained by the female from inside the nest cavity and not from its

mate. In India, male Great Hornbills do not participate in nest sealing activities (James and Kannan 2007). In Thailand, only four out of 15 males were observed supplying sealing materials (Poonswad 1993). Nest sealing provides protection from predators (Kemp 1970) and ensures mate fidelity (Kinnaird and O'Brien 2007).

Feeding

The diet of hornbills in this study was predominately non-fig fruits. Fig fruits were the second highest consumed food for these three hornbill species. Great Hornbills have been reported to favour a non-fig diet (Datta et al. 2003) but the diet differs from that of the Great Hornbills found in Thailand, which was reported to rely heavily on fig fruits instead (Poonswad et al. 1998).

The Rhinoceros Hornbill had been reported to prefer a more fig-based diet (Leighton 1982; Hadiprakarsa 2000). Hornbills select fruits that are abundant, even if they are low in nutritional value. *Polyalthia* spp. and *Ficus* spp. trees produce many fruits and thus these trees were favoured among hornbills (Poonswad 1993). *Polyalthia* spp. seeds were often collected in this study, under the nest trees of the Great and Rhinoceros Hornbills.

The Rhinoceros and Great Hornbills in this study had been seen consuming giant millipedes, a food item that has been reportedly used as sealing material (Kemp 1995). Further feeding observations were interrupted at nest tree RHB01-06 when it became inaccessible due to the presence of a tiger within the area. Feeding observations were also unsuccessful at nest tree RHB02-06 because the male hornbill kept detecting the presence of the observers and would not visit the nest.

Great Hornbills prefer an insect diet once the chick has hatched (Golding and Williams 1986). The absence of a chick may account for the lack of protein-rich food such as animal matter, being delivered by the male to the nest site. The female Great Hornbill in this study spent between 56 - 87 days in the nest cavity before abandoning the nest, exceeding the average 40-day incubation period of the Great Hornbill (Poonswad and Kemp 1993). Due to the absence of protein foods in its food deliveries, the assumption was that no eggs had hatched.

The Helmeted Hornbill preferred a non-fig fruit diet. In a study in Sumatra, Helmeted Hornbills fed exclusively on figs, despite the low fig density in southern Sumatra (Hadiprakarsa et al. 2004). Figs have been documented as an important food source for hornbills and these fruits are available in abundance all year round (Poonswad 1993; Plongmai et al. 2005). A diet consisting of figs helps hornbills maintain a sufficient balance of calcium (Balasubramanian 2004; O'Brien et al. 1998).

Helmeted Hornbills feed on lizards, other birds and their eggs (Kheng 1998). The intake of animal matter increases when a chick hatches as the protein helps the development of the chick. In this study, several stick insects were brought to the nest during the nestling period. The brooding female consumes mostly fruits (Poonswad and Kemp 1993).

In this study, a lone Rhinoceros Hornbill was observed on the ground, on an enormous rotting log. Though hornbills usually forage within the canopy, an Oriental Pied Hornbill had been photographed on the forest ground consuming a fallen fig in Khao Yai National Park (Kitamura et al. 2009). Kemp (2001) had also reported that the Great, Wreathed and Oriental Pied Hornbills descend to the ground to obtain fruits.

Food handling

Among all three species of hornbills observed, the Great Hornbill female regurgitated and dropped the fruits it had been fed. The hornbill's vision makes it most capable of viewing the tip of its own bill. This allows for accurate bill control which helps in feeding activities that involve regurgitation, grasping, swallowing and tossing (Martin et al. 2004). Thus, it appears that the fruits were deliberately allowed to fall. It appears that the male is capable of oversupplying food to the female. The longest time the male Great Hornbill would perch at the cavity was eight minutes, while the shortest time to perch at the cavity was one minute.

Agonistic behaviour

In this study, the Helmeted Hornbill refusal to feed the inmates and loud knocking sounds on the nest tree, were perhaps a means to intimidate and chase the other hornbills away from its nesting area. Both the Rhinoceros and Helmeted Hornbills are known to live as resident territorial pairs (Kemp 1995). The Helmeted Hornbill male, female and chick emitted loud calls at the nest tree in this study, an ideal forest transmission to caution others within a widespread territory (Kemp 1995).

Nest sanitation

All the three species of hornbills in this study practised good sanitation by ejecting faeces out of their nest cavity. Due to the nature of the nest cavity of the Helmeted Hornbill, an accumulation of faeces and fallen fruits often occurred, perhaps due to the young chick(s) inability to defecate outside the nest cavity accurately. Thus, the male Helmeted Hornbill had developed a routine in which after its feeding session, it would fling off debris that had accumulated around the nest cavity's rim. A similar behaviour had been observed in male Indian Grey Hornbills *Ocyceros birostris* (Charde et al. 2011). Observing proper nest sanitation

prevents infestation of parasites and pathogens (Welty et al. 1988; Charde et al. 2011). It also avoids unwanted attention of predators (Weatherhead 1984) and prevents injury to the young chicks caused by the broken sharp egg shells (Charde et al. 2011).

Female departure

The male may have been enticing the female to exit the nest as it remained perched on the nest cavity for 20 minutes, a day before the female's exit. The duet calls of the breeding pair hours before the female's exit may have been a form of encouragement, to persuade the female into leaving the nest. The female did not participate in feeding activities for five days after its exit. This sort of behaviour had also been observed by (Kinnaird et al. 1999) among the female Sulawesi Red-knobbed Hornbill *Aceros cassidix*. According to Kinnaird et al. (1999), if imprisoned for too long, females risk the loss of body mass and atrophy of flight muscles. Thus it is plausible that the female's body was negatively affected and required time to recover upon exiting the nest cavity.

Chick fledging

In most species, it has been learned that food delivery declines as the breeding period proceeds and the breeding pair increases visits to the nest site without food. The adults entice the chick by calling and withholding food, despite begging calls made by the chick (Kinnaird et al. 1999; Kinnaird and O'Brien 2007). A similar behaviour was observed here, with the male using food to entice the chick to abandon the nest. The male made visits to the nest merely to perch with fruit clearly displayed in its bill.

The act of the chick pecking on the sealing material is an indication of its intention to fledge. This behaviour was observed in both the Helmeted and Rhinoceros Hornbill chicks. In captivity, a chick was observed pecking the sealing material, and had emerged the following day (Golding and Williams 1986). The Rhinoceros Hornbill chick (RHB0206) resealed the nest cavity by itself after the female's departure indicating that the source of sealing material originated from within the nest cavity itself. Not all hornbill chicks reseal their nest cavity upon the departure of the female and it is believed to be a natural response from chicks living in low-positioned nest cavities. It helps protect the chick against predators (Kinnaird et al. 1999). In this study, the cavity position was 12 m from the ground.

ACKNOWLEDGEMENTS

This study was conducted under a non-governmental organization, the Malaysian Nature Society (MNS) and was made possible through funding from Sime Darby Plantation. We thank Shumpei Kitamura for his help to identify the fallen fruits and we thank Dr. Robyn Fay Wilson for her comments on this manuscript. The nest tree species were identified by the Forest Research Institute Malaysia (FRIM).

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Table 1. Hornbill nest tree preferences.

Nest Code	Elevation	Tree Description	Photo of Nest Cavity
GHB01-06	267 m asl	Species: Unidentified Height: ~21.3 m Circumference: 3.94 m dbh Cavity height: ~12.2m Tree condition: Alive Status: Active	 Photo credits: Sanjitpaal Singh
HHB01-07	238 m asl	Species: *Dysoxylum grande* Hiern. Height: ~19.8 m Circumference: 2.6 m dbh Cavity height: ~13.7 m Tree condition: Alive Status: Active	 Photo credits: Sanjitpaal Singh
RHB01-06	247 m asl	Species: Unidentified Height: ~ 28.9 m Circumference: 1.91 m dbh Cavity height: ~ 21.3 m Tree condition: Alive Status: Active	 Photo credits: Sanjitpaal Singh
RHB02-06	245 m asl	Species: *Koompassia malaccensis* Maing. *ex* Benth. Height: ~ 19.8 m Circumference: 1.93 m dbh Cavity height: ~12.2 m Tree condition: Alive Status: Active	Not available
RHB03-07	350 m asl	Species: Unknown Height: ~ 24.4 m Circumference: 4.2 m dbh Cavity height: ~ 15.2 m Status: Inactive	 Photo credits: Lim Kim Chye
WRHB01-07	278 m asl	Species: *Terminalia bellirica* (Gaertn.) Roxb Height: ~30.5 m Circumference: 2.7 dbh Cavity height: ~16.8 m Tree condition: Alive Status: Inactive	 Photo credits: Lim Kim Chye

Note: GHB = Great Hornbill, RHB = Rhinoceros Hornbill, HHB = Helmeted Hornbill, WRHB = Wreathed Hornbill

Table 2. Fallen fruits identified as the fruit preferences of Great Hornbill.

Family	**Species**
Moraceae	*Ficus* sp.
Sapotaceae	Unknown
Annonaceae	*Polyalthia* sp.
Elaeagnaceae	*Elaeagnus* sp.

Table 3. Several fallen fruits identified indicating the fruit preferences of the Rhinoceros Hornbill.

Family	**Species**
Moraceae	*Ficus* sp.
Annonaceae	*Polyalthia* sp.
Arecaceae	*Oncospermum* sp.
Sterculiaceae	*Sterculia* sp.
Cornaceae	*Mastixia* sp.
Meliaceae	*Dysoxylum* sp.
Myristicaceae	*Myristica* sp.
Elaeagnaceae	*Elaeagnus* sp.

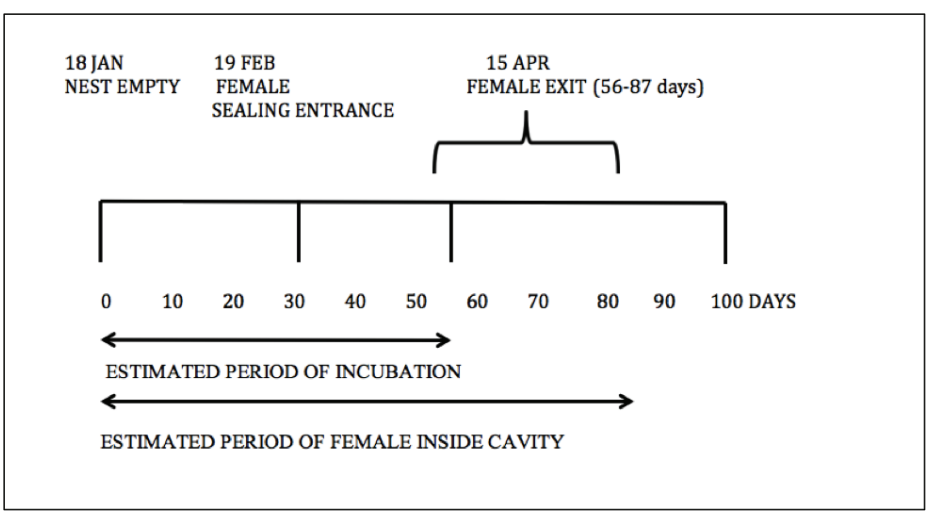

Figure 1. The estimated nesting schedule of the Great Hornbill.

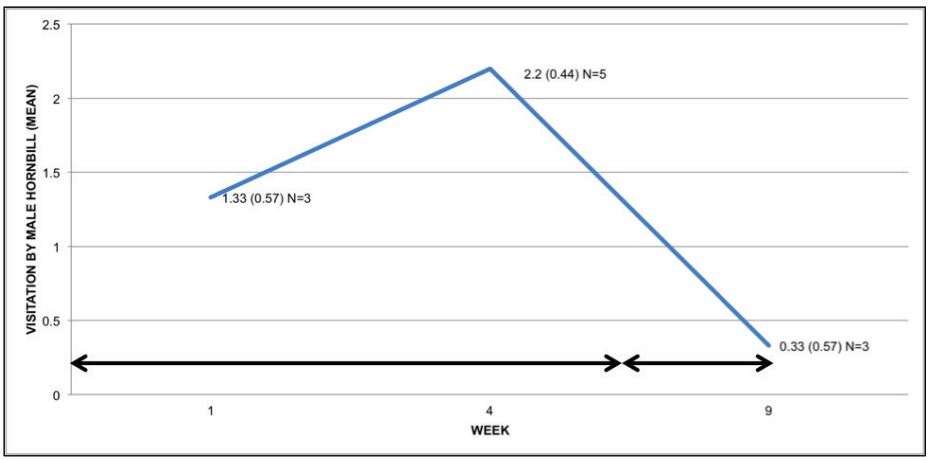

Figure 2. Mean nest visitation by the male Great hornbill by weeks. Standard deviation in parentheses. Only full day observations (8-11.5 hours) presented in this graph.

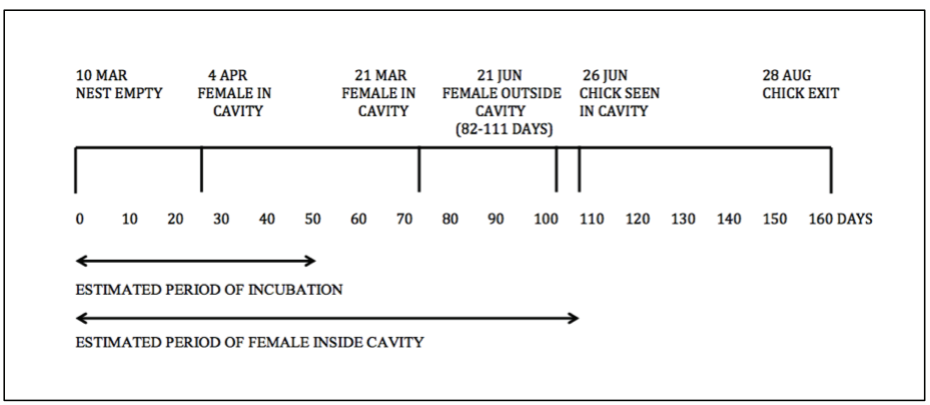

Figure 3. The estimated nesting schedule of the Rhinoceros Hornbill (RHB01-06).

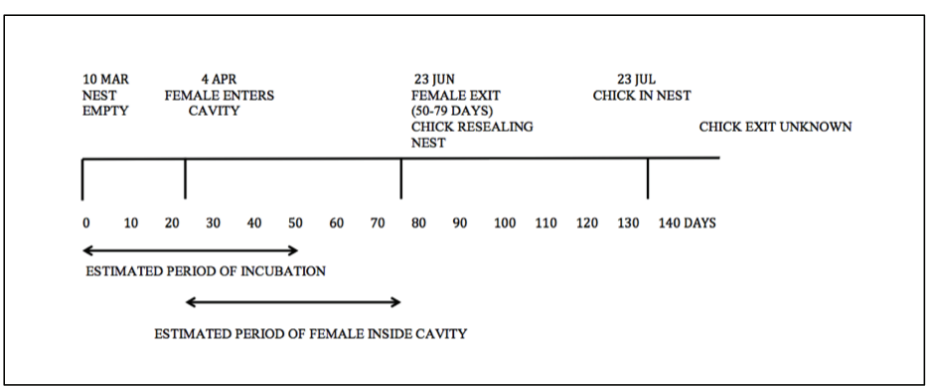

Figure 4. The estimated nesting schedule of the Rhinoceros Hornbill (RHB02-06).

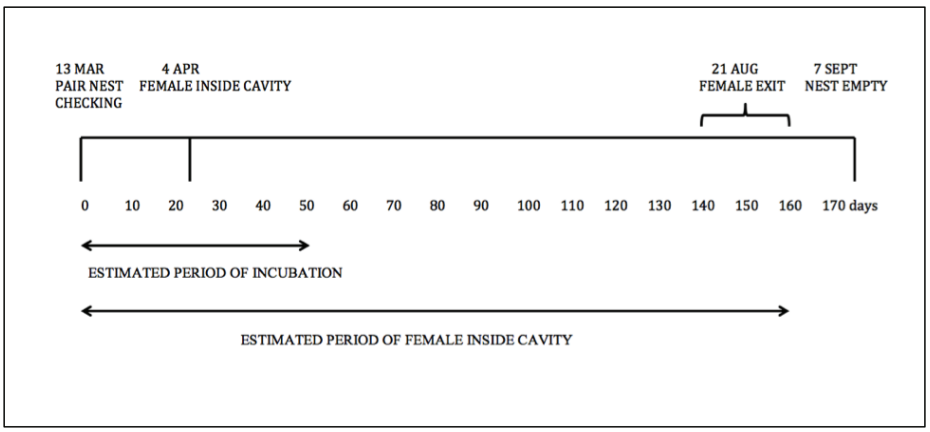

Figure 5. The estimated nesting schedule of the Helmeted Hornbill.

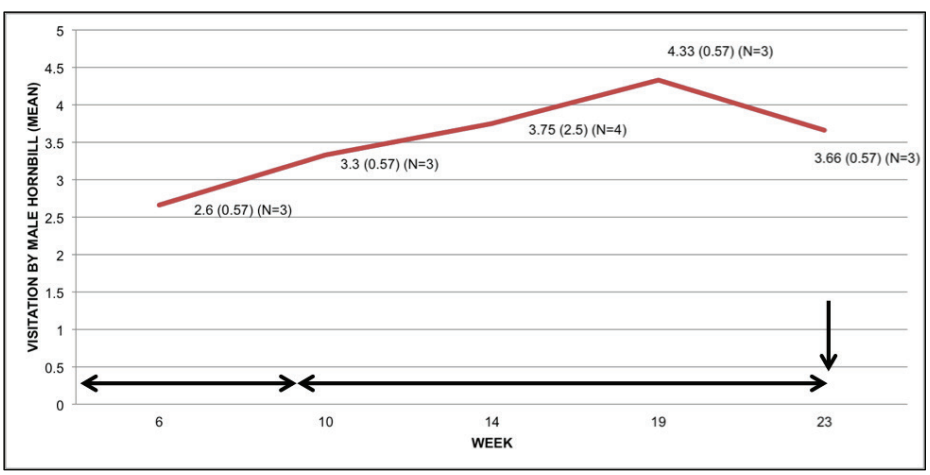

Figure 6. Mean nest visitation by male hornbill by weeks. Standard deviation in parentheses. Only full day observations (8-11.5 hours) presented in this graph.

Malayan Nature Journal 2015, 67(2), 258-264

Trade of 'captive-bred' birds from the Solomon Islands: a closer look at the global trade in hornbills

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Abstract: Southeast Asia is believed to be responsible for an estimated 25% of the global illegal wildlife trade, often involving organised criminal syndicates that spanning throughout Southeast Asia and beyond. Many of the species traded in Southeast Asia are sourced elsewhere before being laundered into the global market. This illegal trade is a major threat to many species of birds, and hornbills are no exception. Increasingly, the origins of species traded internationally are falsely declared. Often, specimens are declared as being captive-bred, when in fact the specimens are wild-caught. This form of fraud is difficult to detect and a lack of monitoring and expertise among enforcement agencies provides an opportunity for unscrupulous dealers to carry out this illegal trade undetected. The Papuan Hornbill *Aceros plicatus* does not lend itself for captive breeding at a commercial scale. In general, hornbills reproduce slowly, have relatively small clutch sizes and take a long time to mature. Yet relatively large volumes of this species have been exported from the Solomon Islands, via Southeast Asia, into the global market, with many of them being declared as captive-bred. From 2002 to 2010, close to 1000 Papuan Hornbills were imported from the Solomon Islands, with more than half being declared as captive-bred. The majority of the hornbills were exported to Singapore. This paper examines this trade, the claims of commercial captive breeding, and sheds light on the large-scale laundering of wild-caught hornbills and other bird species from the Solomon Islands into the global market place.

Keywords: *Aceros plicatus*, CITES, laundering, Papuan Hornbill, wildlife trade

INTRODUCTION

The Papuan Hornbill *Rhyticeros (Aceros) plicatus* has the most easterly distribution of Asia's hornbills, occurring on many islands from the

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Moluccas of Indonesia, across the island of New Guinea and east to the Solomon Islands (Kinnaird and O'Brien 2007). This species is widespread but with a declining population and has been assessed in the IUCN Red List of Threatened Species as Least Concern (BirdLife International 2012). Subsistence hunting occurs in parts of its range (Marshall and Beehler 2007). Commercial trade is not mentioned as a threat to Papuan Hornbills in the IUCN Red List (BirdLife International 2012). It has been included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1992 (CITES 2013a).

In 2005, we became aware that CITES permits were sought by importers to allow the import of dozens of captive-bred Papuan Hornbills originating from the Solomon Islands into the European Union (EU).

With 177 signatory countries ('Parties'), CITES is the most important global initiative to monitor and regulate international trade of plants and animals. CITES regulates trade of nearly 35,000 species and has reduced threats associated with overharvest of imperilled species for international trade (Phelps et al. 2010). Species are included on one of three appendices, with Appendix I generally precluding trade and Appendix II and III allowing for the regulation of trade. International trade in specimens of Appendix II species is authorized by the granting of an export or re-export permit. CITES does not necessitate import permits for trade in Appendix II-listed species, but some Parties, including the EU Member States, require import permits as part of their stricter domestic measures.

In the case of the import and export of wild-caught CITES-listed species, a Non-Detriment Finding (NDF) should be made by the Scientific Authority (SA) of the exporting country, demonstrating that the trade is not detrimental to the wild population of that species. When dealing with captive-bred individuals an NDF is not needed but it needs to be clear that (a) the individuals are derived from a facility that indeed does produce at least second-generation offspring – that is offspring of parents that themselves were born in captivity and (b) that the individuals are indeed captive-bred and not, for instance, wild-caught or the results of eggs collected from the wild that were merely hatched in the facility.

All countries in the EU are Party to CITES but in 2005 the Solomon Islands were not (they became a Party in 2007). When a Party to CITES imports CITES-listed species from a Non-Party country, it is the responsibility of the SA of the importing country to verify that all CITES regulations are met (Note: The first author is a member of the Dutch Scientific Authority giving him privileged information about the import and export of CITES-listed species into the EU. While some of this information spurred us to do our research, all data collected were derived from publically available sources or were obtained through correspondence with relevant parties and individuals.).

MATERIALS AND METHODS

We recently analysed the trade of birds from the Solomon Islands over the last decade (2000-2010), using information provided by Parties and from government officials of the Solomon Islands, and found that in that period tens of thousands of birds declared as 'captive-bred' were exported (Shepherd et al. 2012). Many of the species involved are difficult to breed, virtually impossibly so at a commercial scale. We also revealed that there were no commercial bird breeding facilities present in the archipelago, suggesting large scale laundering of wild-caught birds. Here we expand on this analysis by focusing on the international trade of hornbills from the Solomon Islands over a longer time period but putting this in a global context. The aim is to highlight the failings on the part of Parties at all stages of the trade chain, and to suggest a process of reappraisal of the rules and intentions of the export of captive-bred animals under CITES. The data are by and large derived from the CITES trade database (http://www.unep-wcmc-apps.org/citestrade/). Given that the Solomon Islands was not a Party to CITES for the majority of this period and only submitted their first annual report for 2008, all our analyses are based on data provided by importing Parties. To prevent double-counting, we exclude re-exports, viz. where one country imports hornbills only to export them to a third country.

RESULTS AND DISCUSSION

The hornbill trade from Solomon Islands in a global context

Over the period 1995 (the first record of the Solomon Islands exporting hornbills) to 2011 (the last year for which records are available, albeit incomplete) a total of 1080 Papuan Hornbills were imported from the Solomon Islands. To put this in context, over that period the entire international trade in CITES-listed hornbills (18 species exported from 22 countries) amounted to 1498 individuals. Thus for almost two decades the Solomon Islands dominated the global trade in hornbills, in most periods accounting for over 70 % of the exports (Figure 1).

The very high proportion of trade should have sent warning signs up the CITES chain of command, and should have led to individual Scientific Authorities from importing countries questioning this trade. However, more surprising than absolute numbers is the sheer number of hornbills declared as captive-bred that have been exported from the Solomon Islands.

Trade in captive-bred hornbills

All species of hornbills have a specialised breeding strategy, where the females seal themselves into a nest cavity and remains there until the eggs hatch and the chicks become well grown (Kinnaird and O'Brien 2007). During this period, the male provides food for the female and her offspring (Kinnaird and O'Brien 2007). Clutch sizes are typically small, between two to five eggs, and the period until fledging lasts between 10 to 20 weeks. While many zoos have been successful in breeding several species, it has never been in large numbers and it is difficult to see breeding hornbills as a viable commercial option.

Under CITES there are clear differences between captive-bred (source code C) and captive-born (source code F) stock. In brief, captive-bred refers to at least second generation offspring of parents bred in a controlled captive environment (or first generation offspring from a facility that is managed in a manner that has been demonstrated as capable of reliably producing second-generation offspring in a controlled environment); it does not include individuals born in captivity to wild-caught parents. Captive-born refers to individuals born in captivity to one or two wild-caught parents, *i.e*. the first generation of offspring born in a captive environment.

According to the CITES trade database, over two-thirds of the international trade in hornbills comprises captive-bred ('second generation offspring') individuals and less than 5% comprises captive-born ('first generation offspring') (CITES 2013b). If true, this indicates that breeders hold on to their first generation offspring, and only export progeny from subsequent generations, or at least that a large number of facilities have demonstrated that they are capable of producing second generation offspring. Apart from wild-caught hornbills, the Solomon Islands only ever exported captive-bred hornbills (no captive-born), 688 birds in total. This amounts to almost 70% of all captive-bred hornbill exports globally, greatly exceeding all other countries.

With respect to captive-bred or captive-born hornbills, while most countries in individual years export single birds or pairs (63% of transactions) the Solomon Islands are responsible for 10 out of 18 transactions involving 10 or more birds. In certain years the Solomon Islands exported 40, 50 and up to 480 captive-bred hornbills. The only other countries that claimed to be capable of breeding similar large numbers over this period were Singapore (80 birds exported in 2006, in other years one to seven birds were exported) and Ivory Coast (44 birds exported in 2005, no exports in other years) but these were isolated incidents (Shepherd et al. 2012).

Where do all the hornbills go to and who are the major players

Table 1 provides an overview of the global export of captive-bred individuals of the four most heavily traded species. It is evident that the number of Papuan Hornbills in trade exceeds that of the other species, with most of this trade deriving from the Solomon Islands. Singapore stands out as an important exporter, with significant numbers exported of each of the four species. It is also an important importer, again of all four species. It is relevant to note that these figures exclude re-exports (birds imported from one country and then exported to another).

Over the period 1995-2011 Singapore additionally re-exported six *R. undulatus* and 32 *R. plicatus*, almost all to Japan: this makes Singapore globally the largest re-exporter of hornbills. The EU countries are an important importer of captive-bred hornbills, although no single country stands out. The United Arab Emirates, however, does stand out as a significant importer of hornbills. Most of their imports come from Singapore, although in 2009 they imported 15 captive-bred *Aceros* hornbills (species not known) from Bahrain. Bahrain is not a Party to CITES and it is unclear how they obtained the founder population.

CONCLUSION

We conclude that the dominant role of the Solomon Islands in the global trade of hornbills for over 15 years should have led to closer inspection of these exports. The fact that during this period the Solomon Islands were not a Party to CITES should have made this a priority.

The export of large numbers of second generation captive-bred hornbills (source code C) relative to the number of first generation captive-born (source code F) may indicate that captive-born or wild-caught hornbills were being falsely declared and exported as captive-bred.

The Scientific Authorities of all hornbill exporting countries, especially those exporting significant numbers of hornbills, such as Ivory Coast, Singapore and the Philippines should ensure that a proper NDF has been made, regardless of whether the birds are claimed to be captive-bred of wild caught. In the case of claimed captive-bred birds, they should determine whether captive breeding has indeed taken place, and that wild-caught birds are not being laundered into the international trade, falsely declared as being captive-bred.

Singapore's role as a major importer of captive-bred and wild-caught hornbills, as a re-exporter of captive-bred and wild-caught hornbills, and as an exporter of captive-bred hornbills, with birds originating from a

wide range of locations (Solomon Islands, Taiwan, Ivory Coast) stands out. Given Singapore's prominence in the global hornbill trade, the SA of Singapore perhaps could have been more cautious in allowing the flow of hornbills through their territory. Imports from unlikely source countries for second-generation captive-bred Asian hornbills, such as Ivory Coast, should have been scrutinised to make sure they indeed did conform to the rules and intentions of CITES.

As major importers, the EU and the United Arab Emirates should have been more prudent in checking the origin of the birds they imported. Especially imports from non-CITES Parties, such as the Solomon Islands prior to 2005 and Bahrain need to be accompanied with all relevant documentation.

ACKNOWLEDGEMENTS

We thank Richard Thomas, Yeap Chin Aik, Loretta Ann Shepherd and William Schaedla for comments and suggestions on an earlier draft of this paper.

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Table 1. Global exports of captive-bred hornbills over the period 1995-2011. Listed are the four most heavily traded species, the main exporters and the main importers. Between brackets is the proportion of captive-bred individuals declared in the imports. All data were obtained from the importing countries, excluding re-exports. Range countries are underlined, noting that *A. corrugatus* and *B. rhinoceros* have become extinct from Singapore.

Species	Total	Main exporters	Total	Main importers	Total
Rhyticeros plicatus	780 (62)	Solomon Islands	688 (64)	Singapore	640 (72)
				EU	156 (9)
				South Africa	34 (100)
		Singapore	30 (100)	United Arab Emirates	30 (100)
		Philippines	13 (100)	United Arab Emirates	13 (100)
Aceros corrugatus	85 (88)	Singapore	41 (100)	United Arab Emirates	30 (100)
				EU	11 (100)
		Ivory Coast	20 (100)	Singapore	20 (100)
		Philippines	18 (100)	EU	18 (100)
Buceros rhinoceros	41 (84)	Ivory Coast	12 (100)	Singapore	12 (100)
		Indonesia	8 (100)	Sri Lanka	8 (100)
		Singapore	8 (100)	United Arab Emirates	8 (100)
Rhyticeros undulatus	42 (91)	Singapore	27 (100)	United Arab Emirates	20 (100)
		Taiwan	6 (100)	Singapore	6 (100)

Figure 1. Global international trade in CITES-listed hornbills (3-year running mean, data from importing countries) showing the total number of individuals (green) and the percentage of this comprising imports from the Solomon Islands (purple): mostly the Solomon Islands account for over 70% of the global trade in hornbills. The horizontal line indicates the 100% mark.