Rhinoceros Hornbill (*Buceros rhinoceros*), female breaking out of nest

Hornbill Research in Thailand

Text by **Dr. Pilai Poonswad** Photos by **Thailand Hornbill Project**

Hornbills are well known as one of the most magnificent bird groups in Asian tropical forests. As flagship species, their presence and status reflect the health of the forest ecosystems. Here Dr. Pilai Poonswad provides an update on the important research and conservation work going on in Thailand.

Research sites

Research on hornbills in Thailand has been carried out by the Thailand Hornbill Project (THP), based at the Faculty of Science, Mahidol University, and supported by Hornbill Research Foundation (HRF) for the past twenty years. The THP has conducted ground-breaking research on the breeding biology of hornbills, including their nesting behaviour, nest characteristics, nest plaster materials, food and feeding and breeding success, with further studies continuing on home range, nutrients, influence of availability of suitable nest cavities and dispersal. Long-term monitoring of breeding status was conducted for four hornbill species in Moist Evergreen Forest (70 km^2) at Khao Yai National Park (KYNP), six species in Hill Evergreen Forest (132 km^2) and in Mixed Deciduous Forests (248 km^2) at Huai Kha Khaeng Wildlife Sanctuary (HKK), and six species in Tropical Rain Forest (90 km^2) at Budo-Sungai Padi National Park (BSNP). Hornbills breed once a year. The breeding season at KYNP and HKK is from January to May, whilst at BSNP it is from March to July. Researchers have observed 2,703 nesting-cavity years at KYNP since 1981, 1,615 at HKK since 1990, and 1,437 at BSNP since 1994.

Nesting habits

When nesting, female hornbills seal themselves into a cavity of a large tree. Among 23 genera of nest trees at KYNP, the most important were *Dipterocarpus* and *Cleistocalyx* (formerly *Syzygium*). In HKK, major nest trees are *Cleistocalyx*, *Tetrameles* and *Dipterocarpus*. In BSNP, the major nest trees are Dipterocarpaceae (*Hopea*, *Shorea* and *Nelobalanocarpus*), but *Hopea* is the most important genus, accounting for 40%. Nest plaster material comprises food debris, wood chips, decayed wood and mud. The shape of nest entrances is oval or elongated, and the nest cavity measures about 50 cm deep x 40 cm wide x 100+ cm long.

Hornbills are unable to excavate their own nest cavities, as do woodpeckers. But wood-decaying fungi play key roles in development of cavities in trees. Our study done in KYNP (2004-2008) found that the number of trees with at least one cavity was 15.5% in *Dipterocarpus* and 13.7% in *Cleistocalyx*.

Of a total of 1,137 fungal isolates (i.e. isolated samples) from these tree genera, the highest number was from *Dipterocarpus* (565 isolates) out of a total of 65 species, 49 genera, 31 families and 4 phyla that were identified. Forty species were isolated from live *Dipterocarpus*, 51 from *Cleistocalyx*, 11 from dead *Dipterocarpus* and 10 from dead *Cleistocalyx*.

Apart from these, there were 11 species (16.2%) found exclusively in *Dipterocarpus* and 20 species (29.4%) in *Cleistocalyx*. Four species (6.15%) were found to be common among all these tree species. Identified fungi involved in creating the cavities were almost all soft rot fungi (97%), i.e. *Trichoderma* spp., *Gliocladium* spp. and *Fusarium* spp. and a few white rot fungi (3%), i.e. *Sporotrichum spp*. and *Coprinus sp*.

Natural damage to nest trees and nest cavities obviously affects the breeding success of hornbills by reducing availability of suitable nest cavities. The shortage of nest cavities results in nest competition at KYNP, incidents of which were recorded for as high as 33% of the cavities available. The need for nest improvement by our field staff is 50% in trees of *Dipterocarpus*, 29% in *Cleistocalyx* and 21% in others.

A nest tree is a tree with a cavity and observed hornbill activity, not all of those turn out to be suitable. In KYNP, 201 nest trees were found. Annually, over 26 years and without repair, 35 nests (72% of 50 suitable trees) were used and produced an average of 42 chicks. After 75 nests were repaired, over 16 years, an additional 23 chicks were fledged annually. The average life span of a cavity was about 9 years, but after repair it was extended for another 4 years. The main causes of unsuitability were sunken nest floors (50%) and narrowed or closed entrances (40%).

At HKK, 63 nest trees in Hill Evergreen Forest were located, and 148 in Mixed Deciduous Forest, 211 in total. Annually, over 17 years, only 26 nests (86% of 31 suitable sites) were used and produced 19 chicks (49% success). After 31 nests were repaired over 5 years, an additional 12 chicks were fledged annually. Average life span of a cavity in trees at Hill Evergreen Forest was 6 years, whereas in Mixed Deciduous Forest it was slightly longer at 8 years. In Mixed Deciduous Forest, the unsuitability factors of 19 nests were sunken nest floor (41%) and narrowed nest entrance (36%), while in Hill Evergreen Forest for 12 nests sunken nest floor was 79%.

Helmeted Hornbill (*Rhinoplax vigil*), male at nest.

In Tropical Rain Forest at Budo Mountain, a part of BSNP, 166 nest trees were recorded. Annually, over 15 years, 37 nests were used and produced at least 29 chicks (71% success). The average life span of a cavity was 7 years, and sunken floor was the main cause of unsuitability (63%).

Food and seed dispersal

Although hornbills are omnivorous, their main diets are fruits, varying between 60-95% of the total diet depending on species. Research found that fruits are an important source of all nutrients, especially fat, for four hornbill species at KYNP. Ripe fruits of 139 plant species, from 76 genera and 36 plant families were recorded in the diet of hornbills.

In the hornbill's annual life cycle, fruit species consumed were: 22 species during the pre-breeding season; 63 species during the breeding season and 65 species during the non-breeding season. Major food-plant families were *Lauraceae*, *Moraceae*, *Annonaceae* and *Meliaceae*, but we suggest that delivery of animal protein may be linked, in some way, to breeding success. Animals in the diet comprised 70 species belonging to various groups, including insects and arthropods, amphibians, reptiles, mollusks, crustaceans, fishes, mammals and birds.

Hornbills are able to store many fruits per feeding in the esophagus and stomach, and then regurgitate their seeds as they move, making hornbills significant seed dispersal agents.

To clarify the effect of hornbill loss on seed dispersal in tropical forests, research was done at BSNP and Hala-Bala Wildlife Sanctuary (HBWS) in southernmost Thailand (2005-2008). Mahidol University Government Fund, National Center for Genetic Engineering and Biotechnology (BIOTEC) and HRF, supported the research. The results showed that hornbills consumed at least 89 fruit species and tended to ignore well-protected fruits, fruits of small trees, green-brown fruits, very small fruits (<10mm in diameter), or very large fruits (>40mm in diameter).

Although hornbills had clear feeding preferences for numerous fruit varieties, they also seemed to be quite flexible in eating whatever was available in the forest. Additionally, hornbills also moved over large ranges, 4-35 km² depending on the species, thus enhancing seed dispersion. Therefore, it was predicted that with fewer dispersal agents, there would be less seed removal, higher seed predation and less recruitment of large-seeded plants in fragments than in continuous forests in southern Thailand.

Territories and densities

Studies of home range size for individual males of three hornbill species monitored using radio telemetry at KYNP (1998-1991) revealed that the home range of Great Hornbill was 3.7 km², White-throated Brown Hornbill 4.3 km² and Wreathed Hornbill 10 km2 in the breeding season. In the non-breeding season, the range size of the Wreathed Hornbill (28 km²) was greater than that of the Great Hornbill (14.7 km2). In Hill Evergreen Forest at HKK, the year round home range and habitat utilization of Rufous-necked Hornbills (2004-2006) was 15 km² and of Brown Hornbills was 33 km². At Budo Mountain, estimated mean home

The three areas of study

1 **Khao Yai National Park** is situated in northeast Thailand (14º5'-35' and 101º5'-52'E). It covers an area of 2,168 km². Approximately 90% of forest cover (evergreen forest) are suitable for four species of hornbills. This is the 2008 breeding success of four hornbill species in our study area within the park.

Location	Hornbill species	No. existing nest	No. sealed	No. success	% Success of sealed
Khao Yai N.P.	Great *Buceros bicornis*	43	29	29	100
	Wreathed *Rhyticeros undulatus*	35	16	15	94
	White-throated Brown *Anorrhinus austeni*	24	13	13	100
	Oriental Pied *Anthracoceros albirostris*	*51*	*29*	*29*	*100*
	Total	**153**	**87**	**86**	**99**

2 **Huai Kha Khaeng Wildlife Sanctuary** is situated in western part of Thailand (15˚00'-35'-15˚50'N and 99˚00'-99˚28'E). It covers an area of 2,780 km². Approximately 75% of various forest types (including monsoon evergreen, hill evergreen, mixed deciduous forset and secondary growth) are utilized by 6 species of hornbills. This is the 2008 breeding success of five hornbill species in our study area, no nest of Wreathed Hornbill was found.

Location	Hornbill species	No. existing nest	No. sealed	No. success	% Success of sealed
HKK Wildlife Sanctuary	Great	21	18	12	67
	Rufous-necked *Aceros nipalensis*	10	4	4	100
	Plain-pouched *Rhyticeros subruficollis*	7	5	5	100
	Tickell's Brown *Anorrhinus tickelli*	8	6	6	100
	Oriental Pied	25	21	20	95
	Total	**71**	**54**	**47**	**87**

Bushy-crested Hornbill (*Anorrhinus galeritus*) Hornbill at nesting tree.

3 **Budo Mountain** is a part of Budo-Sungai Padi National Park, which is situated in southern Thailand (101˚30'-101˚40'E and 6˚21'-6˚35'N). It covers an area of 189 km². The area is covered by tropical rainforest, but is experiencing heavy encroachment and conversion to fruit and Para rubber plantation. Approximately 40% of the remaining forest supports 6 species of hornbills. This is the 2008 breeding success of the six hornbill species in our study area.

Location	Hornbill species	No. existing nest	No. sealed	No. success	% Success of sealed
Budo Mountain	Great Hornbill	51	18	16	89
	Rhinoceros Hornbill *Buceros rhinoceros*	38	6	3	50
	Helmeted Hornbill *Rhinoplax vigil*	9	1	1	100
	Wreathed Hornbill	11	1	1	100
	Bushy-crested Hornbill *Anorrhinus galeritus*	11	2	2	100
	White-crowned Hornbill *Berenicornis comatus*	9	0	0	0
	Total	**129**	**29**	**23**	**79**

range of fledglings of Great Hornbills (2006) was 2.1 km^2 and the core area was 2 km^2. Differences in range sizes of different species may relate to breeding strategy and differences in diet within each study area. To gain more detailed insight into home range studies, movement patterns and habitat utilizations of hornbills in the western and north-eastern forests, GPS Satellite Telemetry is currently being used, with financial support from PTT Exploration and Production PCL.

Through awareness of various ongoing threats to hornbill populations, including habitat destruction, poaching and felling of potential nest trees, a five-year grant (2004-2008) from BIOTEC was received. It was for a study of the species diversity, genetic variation and population sizes across the fragmented forest landscape in 12 forest complexes, with intensive study in three main sites from different geographic regions, including the Western Forest Complex (WEFCOM), KYNP and BSNP, all, important habitats for hornbills.

Population density of four species in Mixed Evergreen Forest at KYNP (1,965 km^2) was estimated at 32 individuals/km^2 and for 6 species in Mixed Evergreen Forest, Mixed Deciduous Forest, Hill Evergreen Forest and Dry Dipterocarp Forests at HKK (2,697 km^2) was estimated at 42 individuals/km^2. In the Tropical Rain Forest at BSNP (189 km^2), the estimated population was highest at 47 individuals/km^2. The differences in densities of hornbills between these study sites may be due to differences in the area, type and perhaps the quality of these forests.

Population studies

The genetic variation and differentiation of Great Hornbill populations living in three forest habitats (HKK, KYNP and BSNP), which differ in patch size, habitat integrity and disturbance were compared. Microsatellite DNA markers from Great Hornbills were applied as a tool to track desirable traits. Thirteen polymorphic microsatellite markers were isolated and characterized.

The results indicated that Great Hornbill populations of KYNP showed no significant genetic differentiation at all hierarchical levels and therefore were considered as a single population. Since all Great Hornbill population levels in three different types of forest habitats at HKK showed significant partitioning of genetic divergence, it was postulated that these three subpopulations have different local adaptability for each area.

At Budo, there was statistically significant genetic differentiation present among and within individuals inside the region, but not between subpopulations, and this implied that these three subpopulations in Budo were recently separated.

Comparison of genetic divergence among Great Hornbill populations in three geographic regions (HKK, KYNP and Budo) showed high significant genetic differentiation. Great Hornbill populations of KYNP and HKK showed the least genetic divergence, with the largest divergence observed between populations of KYNP and Budo. These genetic divergences corresponded well to the isolation by distance between those regions.

Phylogenetic relationship among 13 hornbill species in Thailand was determined using the mitochondrial DNA sequences of the complete cytochrome b gene and a D-loop region. The phylogenetic trees indicated that the genus *Rhinoplax* (Helmeted Hornbill), a member of the large-casqued hornbill group, is most closely related to the hornbills of genus *Buceros* (Great and Rhinoceros Hornbills).

Therefore, Helmeted Hornbill is presumed to be the oldest or immediate ancestor of Great and Rhinoceros Hornbills. Conversely, the White-crowned Hornbill (*Berenicornis*), an intermediate-casqued hornbill, was shown by the analysis to be more related to *Buceros* than any of the other species. For the small-casqued hornbills of *Rhyticeros* genus, Wreathed Hornbill (*R. undulatus*) and Plain-pouched Hornbill (*R. subruficollis*) are in the same clade, indicating closely related hornbills of similar shape and color of their casques. This group of hornbills has Rufous-necked Hornbill (*Aceros nipalensis*) as their common immediate ancestor or, in other words, Rufous-necked Hornbill is a living ancestor to hornbills of this linage.

To understand the origin and radiation of Asian hornbills (Bucerotiformes), a dated phylogeny of hornbills using mitochondrial DNA sequences of the cytochrome b gene was compiled. The study included all 15 genera and 31 species of Asian hornbills (23 additional species in the order occur in Africa only).

It was discovered that all clades leading to frugivorous hornbills originated in the mid-Eocene (~48 Millions of years ago) and this explosive radiation coincided with a remarkable floral invasion of Asian rainforests. The invasion commenced when the micro-continent of India reached Asia and its distinctive flora colonized in two waves, one mid-Eocene when offshore the Sunda Shelf, the second late Eocene on collision with the Asian mainland.

In modern rain forests, most flowering-plant species produce fleshy fruits and have their seeds, many of which are large, dispersed primarily by vertebrates. Trees in the proto-Indian forests had similar large seeds and each wave of the Indian floral invasion would have required agents with different seed dispersal abilities, the first for long-distance overwater dispersal, the second including short-distance terrestrial dispersal.

Hornbills, together with Old World fruit pigeons and fruit bats, were available at the time for the first wave, while smaller and/or less mobile taxa only became available or relevant for the second wave. The rapid colonization of the Asian flora seems improbable unless assisted by frugivorous vertebrates, such as hornbills.

Habitat requirements

Remote sensing and GIS were used to compare changes in hornbill habitats (1985-2000). The results showed that at core areas of WEFCOM, the former agricultural areas were reduced by 1% per year after the village relocation conducted by the government during the late 1990s allowed the forest to recover. This resulted in a 0.02 % per year increase of forest area.

The same trend occurred in KYNP but, in contrast, at Budo, agricultural areas increased 6% per year and the forest area decreased by 5% per year, showing an alarming situation for the future of hornbills at Budo Mountain. The results from a distribution model of 9 hornbill species (except species with insufficient data, including Bushy-crested, Wrinkled, and Plain-pouched Hornbills; and also excluding the common Oriental Pied Hornbill that occurs in many places), using an MaxEnt Model, revealed that only 8% of forest areas in Thailand are being occupied by hornbills.

This habitat modeling at a finer scale was done for a single species as well, the Rufous-necked Hornbill in WEFCOM. These models predicted that the distributions of all hornbill species, except for the Oriental Pied Hornbill, were affected by the patch size of the forest habitat.

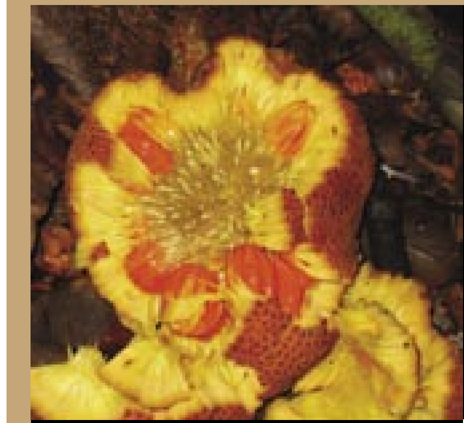
Further, we characterized six different forests that are home to hornbill populations, to identify habitat traits within these various forest communities. The forest sites differed significantly in their structure and tree species diversity, as well as in their relative number of potential food and nest trees.

Trees of known hornbill food species were at relatively high densities at all sites, but they differed in the relative contribution of a few key species and families. Although big trees were found at comparable densities across sites, neither big-tree species diversity nor density could accurately gauge the number of trees in which cavities that hornbills require for nesting could be found.

The combination of a lower percentage of potential nest trees and the predominance of a relatively small group of food tree species in montane and dry evergreen forest could render such habitats less capable of supporting hornbill populations compared to lowland dipterocarp and moist evergreen forests.

The study suggests that detailed information on hornbill food and nest tree species will be required to optimize the management of hornbill conservation areas, as opposed to a quick evalu-

Hornbill Menu



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Animals in the diet comprised 70 species belonging to various groups, including insects and arthropods, amphibians, reptiles, mollusks, crustaceans, fishes, mammals and birds.

This Great Hornbill (*Buceros bicornis*) has taken to an artificial nesting box.

The field staff who makes it all possible.

ation of forest structure and diversity. Moreover, the identification and conservation of core areas for optimal hornbill feeding and nesting habitats will be a useful initiative for the continued presence of these majestic birds in Asian forests.

Adopt a hornbill's nest

Nevertheless, the loss of forest area is not the only factor affecting hornbill survival, since poaching and illegal logging also are important factors. BSNP, one of the main study sites in southernmost Thailand, had experienced heavy poaching.

An intensive campaign was started in 1994. Over 40 villagers (former poachers/illegal loggers) from 13 villages around Budo Mountain participated in our research and conservation programmes. Urban people could also take part through such schemes as hornbill nest adoption, with 1,622 nest-years of adoption to date. The program is now considered successful in terms of poaching eradication and dissemination of the hornbill conservation message to the public. Since 1994, villagers have observed and guarded for 1,303 nest cavity-years and, for these, there has been 70% breeding success and over 400 chicks have fledged.

In our attempt to increase the breeding population of Budo Mountain, the number of suitable nesting sites were increased by providing artificial nests. Nineteen artificial nests were installed at Budo Mountain in 2005 and four species (Great, Rhinoceros, Helmeted and Wreathed Hornbills) checked the nests, but none was used.

In 2006, three species (Great, Rhinoceros and Helmeted Hornbills) came to artificial nests and a Great Hornbill was found in one with a chick. In 2007, two species (Great and Rhinoceros Hornbills) investigated nests and two pairs of Great Hornbills occupied nest boxes. In 2008, the same two species investigated nests and three pairs of Great Hornbills imprisoned themselves. And in 2009, the same two species checked the nests and five Great Hornbills sealed themselves into nest boxes.

The success of the nest adoption program has led to a second phase, the establishment of the Budo Hornbill Conservation & Education Center in 2004 on a piece of land donated by a villager's family. The Center provides educational and conservation lessons for approximately 400 individuals per year to schoolteachers, children, teenagers and villagers in the surrounding area.

Aside from these programs, we are expanding the channel for communication between persons or groups with an interest in hornbills through a Hornbill Network. Presently, 18 local schools surrounding Budo Mountain are members of the Network. Our conservation programs show clear, progressive development of relationships among urban, rural and natural environments, using hornbills as a tool. Consequently, hornbills are being conserved in a sustainable manner.

Academic and government institutes, e.g. the National Park, Wildlife, Plant Conservation Department, Education Ministry and Tourism Authority of Thailand can use and apply the information from each level of success, including our techniques, databases and publications, for the proper management of and for recovery plans in degraded and/ or logged forests.

Hornbill Family Adoption

Year	Total	
	Supporters	No. of nests adopted
1998	59	72
1999	69	106
2000	93	119
2001	83	109
2002	92	128
2003	93	148
2004	103	183
2005	109	206
2006	124	223
2007	106	174
2008	89	171

Anyone who adopts a hornbill nest does not only make in important contribution to nature conservation. He/She will also receive a full report of events at the end of the nesting cycle together with photographs of his/her birds. A visit to the nest during breeding can sometimes be arranged at own cost. Please go to http://www.sc.mahidol.ac.th/research/hornbill.htm and find the link to the Adoption Program at the bottom of the page.

About Dr. Pilai Poonswad

Pilai Poonswad has an M.Sc. in Microbiology from Mahidol University and a Ph.D. in Avian Ecology from Osaka City University, Japan. Her field of expertise is Avian Parasitology and Avian Biology and Ecology. She is the representative of Thailand in the International Ornithological Committee, a founder and committee member of Hornbill Research Foundation and elected as Honorary Fellow of American Ornithologists' Union. She is currently Professor of Biology at the Department of Microbiology, Faculty of Science, Mahidol University, Bangkok, Thailand. Lately she has received numerous honors and awards for her scientific work and contribution to conservation.

HONORS

2009 • Recipient of 2008 *Distinguished alumni* from Graduate Studies of Mahidol University

2008 • Recipient of *2007 The Dushdi Mala Medal for Great Eminence in Science*, awarded by His Majesty King Bhumibhol (King Rama IX)

2007 • Recipient of *2006 Outstanding Lecturer Award (Science & Technology)* from the Council of the University Faculty Senates of Thailand

• Recipient of *2007 National Outstanding Person Award (Natural Resources and environment)* from Prime Minister Office, The Royal Thai Government

• Recipient of *BCST-Swarovski Award 2007 (Outstanding Bird Conservationist)* from Bird Conservation Society of Thailand & Swarovski Optik, Austria

2006 • The first Thai Laureate of *The 2006 Rolex Awards for Enterprise* from Rolex SA, Switzerland

• The first Thai recipient of *The 52nd Annual Chevron Conservation Awards* from Chevron Corporation, USA

• Recipient of *2006 Faculty of Science Outstanding Lecturer Award (Professor level)* from Faculty Senate of Faculty of Science, Mahidol University, Bangkok, Thailand

• Recipient of *2005 Mahidol University Prize for Excellence in Research* from Mahidol University, Bangkok, Thailand