State of Nature Conservation in Malaysia 2025, 359–374
doi: 10.62613/sonc2025.v2fnc02

CHAPTER 2

State of hornbill conservation in Malaysia

CHIN-AIK YEAP[1]*, G.W.H. DAVISON[2] and DING LI YONG[3]

Abstract: Hornbills are widely recognised in Malaysia and hold a deep cultural and spiritual significance to the indigenous communities in Malaysian Borneo. Ecologically, they play an important ecological role as seed dispersers, hence the moniker "farmers of the forest". Ten hornbill species (six genera) are recorded in the country. Small Malaysian states support at least one species, and larger States, usually with large forest areas, can support up to ten species. This paper provides a broad overview of hornbill distribution, ecology, population status, and conservation based on published and unpublished sources, and insights from past and present conservation and citizen science efforts in the country.

INTRODUCTION

Hornbills are iconic birds in the semi-tropical and tropical forests of Asia. To birdwatchers, hornbills are regarded as 'must-see' species in birdwatching trips in pristine forests such as Taman Negara in Peninsular Malaysia and Danum Valley in Sabah (Yong and Low 2018). Culturally, the indigenous Dayak communities of Borneo revere the Rhinoceros Hornbill (*Buceros rhinoceros*), which symbolises purity and strength (Aquarini *et al*. 2022). In Sarawak (East Malaysia), this hornbill species is recognised as the official state bird and is depicted in the state emblem—though it is not Malaysia's national bird, contrary to what is often mistakenly depicted in social media platforms. Ecologically, hornbills consume fruit of many plant species and broadcast the regurgitated or defaecated seeds throughout the forest landscape where they can germinate (Kinnaird and O'Brien 2007; Kitamura 2011). Hence, hornbills are now popularly known as 'farmers of the forest'.

To date, 32 hornbill species (family Bucerotidae) are recognised and spread across 19 range countries (Poonswad *et al.* 2013; Kemp 1995). Indonesia and Thailand have the highest hornbill diversity per country, with 13 species each, followed by Malaysia, Myanmar and the Philippines, each with ten species. Six (*Anthracoceros*, *Berenicornis*, *Anorrhinus*, *Rhabdotorrhinus*, *Rhyticeros*, *Buceros*, and *Rhinoplax*) of the 11 Asian hornbill genera occur in Malaysia. In this context, Malaysia is an important range country for Asian hornbills. Until the 1990s, Malaysia was thought to support nine species, until the Plain-pouched Hornbill (*Rhyticeros subruficollis*) was accepted as the tenth hornbill species in 2000 (Chew and Supari 2000; Records Committee, MNS-BCC 2000). The seasonal presence of hundreds of Plain-pouched Hornbills, first detected in northern Peninsular Malaysia, was attributed to the commoner Wreathed Hornbill (*Rhyticeros undulatus*) before mounting evidence proved it to be a distinct species (Rasmussen 2000).

DISTRIBUTION WITHIN MALAYSIA

Hornbill species distribution differs geographically in Malaysia. All ten species occur in Peninsular Malaysia while Sabah and Sarawak have eight species (Chasen, 1939; Smythies 1999; Wells 1999; Khusaini *et al.* 2015). The Great (*Buceros bicornis*) and Plain-pouched

[1] Malaysian Nature Society, JKR 641, Jalan Kelantan, Bukit Persekutuan, 50480 Kuala Lumpur.
[2] National Parks Board Singapore, 1 Cluny Road, Singapore 259569
[3] BirdLife International (Asia Division), 354 Tanglin Road, #01-16/17, Tanglin International Centre, Singapore 247672
***Corresponding author: hornbills@mns.org.my / msiahornbill@gmail.com**

Hornbills do not occur in Borneo. As almost all hornbill species depend on forests for survival, Malaysian States with remaining sizable forest landscapes generally support high hornbill diversity (Table 1). Perak and Kedah are the only states to have ten species each. Johor, Pahang, and Terengganu support nine species each while Selangor, Negeri Sembilan, Sabah and Sarawak have eight species respectively. Despite being less than 1% of Peninsular Malaysia's landmass, Perlis also supports eight species—all found in Perlis State Park. Surprisingly, only six species have been recorded in Kelantan despite the available forest area. In small States such as Pulau Pinang, Federal Territory Kuala Lumpur, and Melaka, one to three species are encountered. Two hornbill species, the Great and Oriental Pied (*Anthracoceros albirostris*), do occur on islands such as the Langkawi archipelago (Kedah), Pulau Pangkor (Perak), and only Oriental Pied on Pulau Gaya and Pulau Tiga (Sabah) (Sheldon *et al*. 2001; Yeap 2005; Mohd-Taib *et al.* 2019). The Langkawi Archipelago likely supports the largest breeding population of Great Hornbills off the mainland Peninsular Malaysia, where more than 100 individuals have been counted (Hassan and Yatim 2003). However, hornbills are strangely absent in the islands off the east coast of Peninsular Malaysia (e.g., Pulau Tioman, Pulau Redang).

Table 1. The number of hornbill species recorded in Malaysian States, and current forest cover.

State	State area (ha)	Forested area (ha)[a]	Protected area (ha)[b]	No. of hornbill species
Peninsular Malaysia*				
(i) Perlis	81,313	11,140	68	8
(ii) Kedah	946,616	343,466	2	10
(iii) Pulau Pinang	105,916	6,063	2,508	1
(iv) Perak	2,087,573	987,963	4,711	10
(v) Selangor	790,781	250,987	9,892	8
(vi) Federal Territory (Kuala Lumpur, Labuan & Putrajaya)	38,615	153	24	1[c]
(vii) Negeri Sembilan	665,846	154,934	216	8
(viii) Melaka	167,018	5,187	99	3
(ix) Johor	1,908,812	334,491	157,619	9
(x) Pahang	3,592,987	1,588,596	350,734	9
(xi) Terengganu	1,295,725	540,309	103,082	9
(xii) Kelantan	1,503,637	629,881	91,440	6
Subtotal (A)	**13,184,839**	**4,853,170**	**720,395**	
Sarawak**	7,650,000	3,950,000	2,118,249	8
Sabah***	4,600,000	3,575,035	274,129	8
Subtotal (B)	**12,250,000**	**7,525,035**	**2,392,378**	
TOTAL (A+B)	**25,434,839**	**12,378,205**	**3,112,773**	**10**

*Based on Forestry Department Peninsular Malaysia Annual Report 2024.
**Based on Sarawak Forestry Department Annual Report 2023.
***Based on Sabah Forestry Department Annual Report 2024.
[a] Forested Area refers to Forest Reserves in Peninsular Malaysia and Sabah, and Permanent Forest Estates in Sarawak.
[b] Protected Areas refers to National Park, Wildlife Reserve, Wildlife Sanctuary, Birds Sanctuary, Ramsar Sites in Peninsular Malaysia, National Parks, Wildlife Sanctuaries, Nature Reserves, Marine Parks, Wildlife Rehabilitation Centres in Sarawak, and Parks, Wildlife Sanctuaries, Conservation Areas in Sabah.
[c] Kuala Lumpur only.

Hornbills are typically found in most well-forested landscapes in Malaysia. Madoc (1947) remarked that "*most of them are resident in virgin jungle, extending from the mangrove belt to the mountain tops*". Wildlife/biodiversity surveys and birdwatcher sightings in Malaysia have shown that hornbill diversity is greatest in the lowland forests (<300 m a.s.l.), i.e. freshwater/peat swamp to lowland dipterocarp forest, where all ten species can be found. Hornbill diversity then declines gradually from hill to upper dipterocarp forests as elevation increases (Table 2). Only two to five species, i.e. Bushy-crested (*Anorrhinus galeritus*), Wreathed, Great, Rhinoceros, and Helmeted Hornbills (*Rhinoplax vigil*) occur in forests above 1,000 m a.s.l.. Mangroves and coastal vegetation support only a single hornbill species. The Wrinkled Hornbill (*Rhabdotorrhinus corrugatus*) is regarded as a habitat specialist as they prefer peat/freshwater swamp forests (BirdLife International 2026) though it can be seen in or overflying other forest types. The Oriental Pied Hornbill has adapted well to human-modified landscapes such as wooded parks, orchards, gardens, and agricultural lands (Wells 1999; Azhar *et al.* 2011; Jeyarajasingam 2012). They have even been spotted in cities, e.g. Federal Territory Kuala Lumpur, Kuantan, Miri, and Melaka (Tisen and Abang Arabi 2015; Nair 2019; Murali 2020).

Table 2. Hornbill species according to altitudinal distribution and vegetation type* in Malaysia. (Adapted from Smythies 1999; Wells 1999; Harris *et al.* 2012; Jeyarajasingam 2012).

Vegetation Type*	Altitude (m a.s.l.)	Oriental pied	Black	Bushy-crested	White-crested	Wrinkled	Wreathed	Plain-pouched	Great	Rhinoceros	Helmeted	Total number of species
Mangrove	0 – 299	■										1
Coastal vegetation		■										1
Freshwater / peat swamp		■	■	■	■	■			■			6
Lowland dipterocarp		■	■	■	■	■	■	■	■	■	■	10
Hill dipterocarp	300 – 749	■	■	■	■	■	■	■	■	■	■	8
Upper dipterocarp	750 – 1,199	SVV	■	■	■		■	■	■	■	■	8
Montane oak	1,200 – 1,499	VV		■			■		■	■	■	5
Upper montane	≥ 1,500	ZV					■				■	2
Total no. of vegetation types occupied			4	5	4	3	5	3	5	4	5	

Note: *Vegetation classification follows the Forestry Department Peninsular Malaysia.

FOOD PLANTS AND FEEDING ECOLOGY

Asian hornbills and several plant families in the tropical forests have co-evolved together thus retain a close ecological relationship (Viseshakul *et al.* 2011). Hornbill gape sizes (30 – 55 mm) allowed them to exploit and consume many fruit tree species in the rainforest (Corlett 1998, 2017; Kitamura *et al*. 2004; Liang *et al*. 2024). Mid- to large-sized Asian hornbills consume more fruit than small-sized hornbills (e.g., *Anthracoceros*, *Berenicornis*, *Annorhinus*) (Kitamura *et al.* 2004). Cumulatively, Asian hornbills consume fruits of 495 plant species (46 families) (Kinnaird and O'Brien 2007). An unpublished report by Chai and Yeap (MNS Hornbill Conservation Project, unpublished data) that analysed data from local Malaysian journals showed that the six most dominant food plants consumed by hornbills in Malaysia belong to the Lauraceae, Moraceae, Meliaceae, Myristicaceae, Euphorbiaceae, and Annonaceae plant families. Documenting and observing hornbill feeding behaviour in the forests is generally difficult and time-consuming. In Malaysia, most knowledge is derived from opportunistic birdwatching and a handful of hornbill field research projects (Madge 1969; Andrew 1982; Pan 1987b; Lambert 1989; Smythies 1999; Wells 1999; Kaur et al. 2015, 2018; Yeap et al. 2016; Rahman et al. 2019; Yeap 2025).

The consumption of figs (*Ficus* spp.) by hornbills is well-known (Kinnaird and O'Brien 2007). The Helmeted Hornbill is regarded as a 'fig specialist' as their diet consists largely of figs (Lambert 1989; Kinnaird and O'Brien 2007; Kaur *et al*. 2018). Despite their poor nutritional value (Leighton 1982), figs sustain frugivorous animals through periods when other fruit sources are scarce or unavailable (Leighton and Leighton 1983; Lambert and Marshall 1991). Compared to seasonal fruits, figs do not have a distinct fruiting pattern, and monthly rainfall is not known to influence fruiting episodes (Lambert and Marshall 1991). In the Belum-Temengor Forest Complex (BTFC), Perak, hornbills continue to rely on figs after the peak fruiting period of other trees (July to September) (Yeap 2025). In Malaysia, hornbills have been documented consuming at least 26 fig species (*The Figs of Borneo*, n.d.; Lambert 1989; Lambert and Marshall 1991; Wells 1999; Kaur *et al.* 2018) (Figure 1). The Rhinoceros, Helmeted, Black and Bushy-crested Hornbills each consume more than ten fig species. In a study by Lambert (1989), the Helmeted, Rhinoceros, Black, and Bushy-crested Hornbills consumed figs on more than 50 occasions in three years in Tengku Hassanal Wildlife Reserve (formerly Krau Wildlife Reserve). Lambert's (1989) work remains the only long-term research on the relationship between birds and figs in Malaysia to date. In Kinabatangan Wildlife Sanctuary, a nesting pair of Helmeted Hornbills depended mainly on four fig species to feed the chick (Kaur *et al*. 2018).

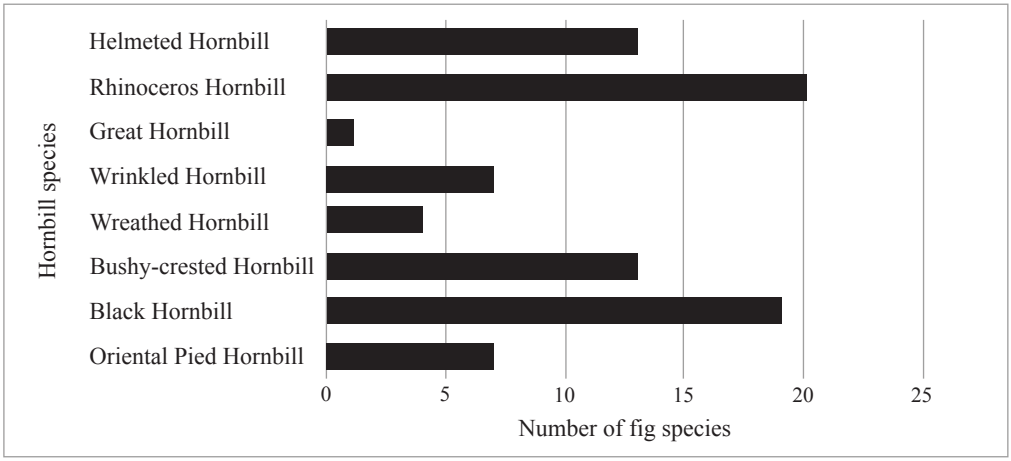

Figure 1. The number of fig (*Ficus*) species known to be consumed by hornbills in Malaysia. (Note: Sample sizes (numbers of observations) are not standardised.)

Apart from consuming fruits, hornbills have been recorded hunting small mammals, small birds, reptiles, and insects in forests and urban/semi-urban areas (Wee 2023). In Sabah, the Oriental Pied and Bushy-crested Hornbills have learnt to catch Wrinkle-lipped Free-tailed Bat (*Mops plicatus*) emerging from caves in the Kinabatangan area (Amar-Singh 2025; Tella *et al.* 2025). They have also been documented catching edible-nest swiftlets (*Aerodramus fuciphagus*) as they leave the entrance to their "swiftlet motel" (Chong *et al.* 2021). The White-crowned Hornbill also consumes a large proportion of animal prey in their diet (Poonswad *et al.* 2013).

NESTING RESOURCES AND ECOLOGY

Hornbill nests are incredibly hard to locate in the forests. Hornbill pairs are often secretive during their nesting period, making them hard to observe. Information on nesting hornbills and their breeding period in Malaysia is patchy and not well defined (Madge 1969; Johns 1982; Pan 1987a, 1987b; Smythies 1999; Wells 1999; Styring et al. 2002; Chong 2011;

Anuar Abdullah McAfee, pers. comm.). Hornbills have been reported in different stages of nesting between January and August based on extant information (Wells 1999) (Table 3). Long-term hornbill monitoring in BTFC revealed that nine hornbill species (except Plain-pouched Hornbill) generally start nesting from February, with chick(s) fledging between May and July (MNS Hornbill Conservation Project, unpublished data). Hornbill pairs would extend their nesting period well into August if they start late in the season. The breeding patterns of hornbills in BTFC corresponded with the flowering and fruiting season—hornbill chick(s) fledged at the height of the fruiting season in June and August. However, Helmeted Hornbills do not seem to have a defined nesting period (MNS Hornbill Conservation Project, unpublished data).

Table 3. Breeding months of the hornbills in the Belum-Temengor Forest Complex (BTFC) and other locations in Malaysia.

Hornbill species	Month												References
	J	F	M	A	M	J	J	A	S	O	N	D	
Outside the Belum-Temengor Forest Complex													
Oriental Pied Hornbill	■	■	■	■	■	■							4,5,7,11
Black Hornbill	■	■		■									6, 7
Bushy-crested Hornbill	■	■	■		■	■	■	■		■			3, 6, 10, 13, 14
White-crowned Hornbill					■	■						■	6, 7
Wrinkled Hornbill	No information												n/a
Wreathed Hornbill	No information												n/a
Great Hornbill	■	■	■	■	■	■							11
Rhinoceros Hornbill	■	■	■	■	■								2, 7, 11
Helmeted Hornbill					■	■	■	■	■	■			1, 7, 8, 11
Within the Belum-Temengor Forest Complex													
Oriental Pied Hornbill	■	■	■	■	■	■							12
Black Hornbill			■	■	■	■	■						12
Bushy-crested Hornbill	■		■	■	■	■				■			12
White-crowned Hornbill			■				■	■					12
Wrinkled Hornbill			■	■	■	■	■	■					12
Wreathed Hornbill	■	■	■	■	■	■	■	■	■				12
Great Hornbill	■	■	■	■	■	■							9, 12
Rhinoceros Hornbill			■	■	■	■	■	■	■				9, 12
Helmeted Hornbill				■	■	■	■	■	■	■	■	■	9, 12

Notes: n/a = Not available

(i) [1] Chong (2011), [2] Johns (1982), [3] Madge (1969), [4] Pan (1987a), [5] Pan (1987b), [6] Smythies (1999), [7] Wells (1999), [8] Kaur *et al.* (2018), [9] Kaur *et al.* (2015), [10] Styring *et al.* (2022), [11] A. A. McAfee (personal communication, April 15, 2018), [12] MNS Hornbill Conservation Project (unpublished data), [13] Lim *et al.* (2020), [14] Wong (2020)

(ii) There are no observations of Plain-pouched Hornbill breeding in Peninsular Malaysia.

For nesting, hornbills often select cavities in trees that are (1) tall and large, (2) commonly found or locally abundant in their area or site, and (3) durable (Poonswad 1995) as they are often reused in the following nesting season. In BTFC, hornbills nested in trees of eight families, i.e., Dipterocarpaceae (four species), Fabaceae (four), Tetramelaceae (one), Meliaceae (one), Euphorbiaceae (one), Sapotaceae (one), Combretaceae (one) and Moraceae (one) (Table 4). The mean diameter at breast height (dbh) of nest trees ranged between 81.2 and 122 cm, depending on species (Table 4). Nine resident hornbill species in BTFC have been confirmed breeding by the MNS Hornbill Conservation Project in the landscape—an effort that took 14 years to achieve, which underscores the difficulty in locating hornbill nests in the forest. The exception is the Plain-pouched Hornbill, which may breed there but is so far known only as a seasonal migrant. Elsewhere in Malaysia,

six hornbill species have been documented nesting in trees of the Meliaceae (*Xylocarpus* sp.), Dipterocarpaceae (*Shorea pauciflora*, *Shorea* sp. 1, *Shorea* sp. 2), Fabaceae (*Koompassia excelsa*), Sapindaceae (*Pometia pinnata*), and Myristicaceae (*Myristica* sp.) families, as well as five unknown tree species (Chasen 1939; Madoc 1947; Pan 1987b; Noramly 1998; Wells 1999; Styring *et al*. 2002; Chong 2011; Kaur *et al.* 2018). To date, hornbills have been reported breeding in Kedah, Perak, Selangor, Pahang, Johor, Terengganu, Sarawak and Sabah based on direct (nest tree) and indirect evidence (presence of juveniles) (Yeap *et al.* 2023). This points to the frequency of observations rather than the distribution of hornbill breeding.

Table 4. Nest tree measurements used by nine hornbill species in Belum-Temengor Forest Complex. (MNS Hornbill Conservation Project, unpublished data).

Species	Nest Tree GBH Range		Mean GBH (cm)	Mean DBH (cm)	Tree Family
	Low (cm)	High (cm)			
Oriental Pied Hornbill	110	429	255	81.2	Dipterocarpaceae, Fabaceae, Tetramelaceae, Euphorbiaceae
Black Hornbill	150	374	220	70.1	Dipterocarpaceae, Fabaceae, Euphorbiaceae
Bushy-crested Hornbill	140	462	276	87.9	Sapotaceae, Dipterocarpaceae, Fabaceae, Tetramelaceae
White-crowned Hornbill	172	323	248	79.0	Dipterocarpaceae, Euphorbiaceae
Wreathed Hornbill	259	399	295	93.9	Dipterocarpaceae, Combretaceae
Wrinkled Hornbill	226	231	229	72.9	Moraceae
Great Hornbill	192	394	292	93.0	Fabaceae, Tetramelaceae, Dipterocarpaceae
Rhinoceros Hornbill	191	730	312	99.4	Fabaceae, Tetramelaceae, Dipterocarpaceae, Euphorbiaceae
Helmeted Hornbill	250	483	383	122.0	Meliaceae, Fabaceae, Dipterocarpaceae

Note: GBH = girth at breast height / DBH = diameter at breast height.

Extraordinarily, Oriental Pied Hornbills have also been documented nesting recently in a karst limestone cavity around Ipoh city (Amar-Singh and Chiu 2024). This behaviour was attributed to a lack of suitable and available natural cavities in the area frequented by the hornbill pair, as large old trees have been chopped down by the city council in favour of replanting other plants for landscaping. At Halong Bay (Vietnam), the same species inhabits many limestone islands that lack both large trees and natural predators, and presumably also nests in rock cavities (Beharrell and Ryder, 2004; G.W.H. Davison, pers. comm.) In Sungai Panjang (Selangor), these hornbills nested in large earthenware water jars for several years (Ismail *et al.* 2015). Recent social media postings amazingly captured Oriental Pied Hornbill pairs sealing letterboxes that were encased in cement gate pillars. Their use of non-tree, and even man-made structures as alternatives to natural tree cavities showcases the resilience and adaptive behaviour of Oriental Pied Hornbills, contrasting with the more specialised nesting conditions required by deep forest specialists.

HORNBILL POPULATION STATUS IN MALAYSIA

Population estimates of the ten hornbill species in Malaysia are presently unavailable, as no national or state-level population census has been attempted. Site-specific, short surveys in protected and non-protected areas have produced some preliminary estimates on hornbill abundance and density through line or belt transects (Kemp and Kemp 1974; Davies and Payne 1982; Lakim and Biun 2005; Mohd Jamil *et al.* 2015; SFC 2017; Davies 2022) (Table 5). In the latter, estimates were largely derived from logging-wildlife studies or assessments in forest reserves (Dahaban 1994; Hussin 1994; Johns 1987; WWFM 1998; Mohd-Azlan *et al.* 2023).

Table 5. Density estimates for 10 hornbill species in protected and non-protected areas in Malaysia.

Species	Status		References*
	Protected Area (individuals/km^2)	Non-Protected Area (individuals/km^2)	
Oriental Pied Hornbill	1	0.1	1, 2
Black Hornbill	0.3 – 2.3	0.6	1, 3
Bushy-crested Hornbill	0.2 – 3.4	0.3 – 1.0	1, 3, 4, 5,
White-crowned Hornbill	0.4	0.8	3
Wrinkled Hornbill	1.6	0.1 – 1.6	3, 4
Wreathed Hornbill	1.2	0.2 – 0.8	4
Plain-pouched Hornbill	No estimate	No estimate	No reference
Great Hornbill	No estimate	No estimate	No reference
Rhinoceros Hornbill	0.5 – 1.0	0.2 – 2.3	1, 3, 4, 5, 6
Helmeted Hornbill	0.2 – 1.9	0 – 2.5	1, 3, 4, 7, 8

Notes: [1] Medway and Wells (1971), [2] Mohd Jamil *et al.* (2015), [3] Kemp and Kemp (1974), [4] Johns (1987), [5] Meredith (1995), [6] Dahaban (1994), [7] Davies (2022), [8] Bennett *et al.* (1997).
*Several studies i.e. SFC (2017), Davies and Payne (1982), Hussin (1994), WWF-Malaysia (1998), Mohd-Azlan *et al*. (2023) were not included in the Table above as hornbill densities were not expressed in different ways and not convertible to the metric used. In Lakim and Biun (2005), hornbill densities were not estimated under usual conditions, as explained in the text below, thus excluded as well.

In intact forest landscapes, hornbill density typically varies between 0.1 – 3.4 individuals/km^2 depending on species. However, density estimates in the Tawau Hills Park (Sabah) showed were unusually high for the Oriental Pied (19.7 individuals/km^2), Black (7.1), Bushy-crested (26.3), Wreathed (11.2), and Rhinoceros Hornbills (5.7) (Estimates not included in Table 5) (Lakim and Biun 2005). These high figures were attributed to hornbills that were attracted to a fruiting fig tree at the time of the census. The availability of hornbill -preferred fruits (figs and non-figs) can attract an influx of hornbills into an area, thus inflating hornbill numbers temporarily (Ardiantiono *et al.* 2020; Koid *et al*. 2021). The numbers also reflect difficulty in defining the boundaries of survey areas when calculating densities of species that can potentially travel long distances. In BTFC, the seasonal arrival of Plain-pouched Hornbills coincides with the peak fruiting period between July and September (Kaur *et al.* 2011; Yeap *et al*. 2015). After September they leave the landscape and are thought to migrate back to southern Thailand. On islands, hornbill density estimates can also be higher than on the mainland, possibly due to island size, reduced interspecific food competitors, reduced predator diversity, or easier definition of study area boundaries. In Pulau Tiga Park (Sabah), a high density of Oriental Pied Hornbills (19.7 individuals/km^2) was reported in a 6.1 km^2 area (Lakim and Biun 2005).

Wildlife assessments in logging concessions in forest reserves in Peninsular Malaysia and Sarawak have also yielded some hornbill density estimates. Hornbill density for eight species in four different-aged, logged concessions in Sungai Tekam (Pahang, Malaysia) was low (Johns 1987). The Bushy-crested, Wreathed, Rhinoceros, and Helmeted ranged from 0.4 – 1.7 individuals/km^2 in the primary forest but dropped to 0 – 1.8 individuals/km^2. The Helmeted Hornbills showed a high density of 2.1 individuals/km^2 in a three- to four-year -old logged concession, which was unexpected as it was higher than in the primary forest (1.7 individuals/km^2). The Great Hornbill was not recorded in any of the post-logged concessions. The Black and White-crowned Hornbills were present in the three- to four-year-old and above logged forests. The Wrinkled Hornbill was hardly detected in primary and logged forests.

In Terengganu, six hornbill species (Black, Bushy-crested, Wreathed, Wrinkled, Rhinoceros, and Helmeted) were detected in a wildlife assessment of nine forest compartments of three different age groups (virgin, newly logged, and old logged) (WWFM 1998). Hornbill density estimates were unsurprisingly highest in virgin compartments, ranging between 2.2 – 6.5 individuals/km^2. Newly logged compartments reported between 0.8 – 2.4 individuals/km^2. Old logged compartments supported between 1.6 – 2.3 individuals/km^2, indicating perhaps Helmeted Hornbills returning to these regenerated compartments.

In Sarawak, Mohd-Azlan *et al.* (2023) reported similar findings, using relative abundance rather than density. Primary forests, or treated as future logging coupes in their surveys, supported seven of the eight hornbill species found in Borneo. The Wreathed Hornbill was not detected. In the current and recently logged coupes, the number of hornbills detected dropped (31 – 33 detections) compared to the future logging coupe (36 detections). Generally, hornbills can survive in post-logged forests as shown by several studies but most populations do not recover fully (Meijaard *et al.* 2005). This situation is exacerbated when hunting or poaching occurs in logging concessions, further suppressing hornbill population numbers (Datta 1998).

THREATS TO HORNBILLS

Forest loss and fragmentation is undoubtedly the single most destructive threat to hornbills in south-east Asia, including Malaysia (Lambert and Collar 2002). Much of the plains-level forests (<150 m a.s.l.) have been logged or cleared for rubber and oil palm cultivation which would have deprived hornbill populations of nesting trees and food resources. Forest fragmentation has many impacts: reduced patch size, increased edge, reduced ratio of undisturbed core to disturbed fringes, greater travel distances for hornbills across non-forest food-poor environments, and greater chances of human intrusion. There might also be greater susceptibility of small forest patches to droughts, greater drying leading to greater fire risks, wind exposure, all leading to impacts on tall emergent forest trees, lesser tree species diversity, and food shortages such as elimination of fig species which fruit asynchronously and in intact forests, fill in seasonal food gaps (Lambert and Collar 2002). Hornbill-rich habitats, primarily extreme lowland dipterocarp and peat/freshwater swamp forests, are now a fraction of their former size. Remaining forests continue to be subjected to further pressures of being converted into timber plantations of fast-growing exotic species, durian plantations, infrastructure projects, and rare earth element (REE) prospecting and mining.

Although fragmented forest habitats could still support some hornbills, the diversity and population size are expected to be much reduced (Sodhi 2002; Atikah *et al.* 2025). Smaller hornbills such as Oriental Pied and Bushy-crested Hornbills could continue to persist in reasonably-sized fragments. Large hornbills such as the Rhinoceros, Great, and

Helmeted Hornbills would most certainly perish in forest fragments over time, with remnant birds or post-breeding dispersers from other areas giving a misleading impression of continued survival. Wreathed Hornbills, which are nomadic by nature, are likely to move between forest landscapes and fragments. In a citizen science project carried out in 2009 and 2010 by the MNS Perak Branch, birdwatchers recorded only three hornbill species in small-sized forests (1,000 – 9,999 ha) and only encountered six species in large-sized forests (≥10,000 ha) (MNS Hornbill Conservation Project, unpublished data). The most commonly encountered hornbill species were the Oriental Pied and Rhinoceros.

Poaching and hunting are affecting several hornbill species in southeast Asia. The Helmeted Hornbills crisis which erupted in 2016 has decimated populations in Indonesia (Beastall *et al.* 2016). Demands for luxury trinkets and jewelry and ornamental objects of carved Helmeted Hornbills from East Asian markets fueled the trade. There were concerns if (or when) the demand grew, Malaysia could be targeted as the next 'source country'. Two cases of Helmeted Hornbill seizures have been reported to date and are under investigation. In those cases, the casques were likely to have originated from Indonesia (Anon. 2016). However, Malaysian authorities have seized several live juvenile hornbills from Kuala Lumpur International Airport, most of which were Rhinoceros and a single Helmeted (Anon. 2021). In Peninsular Malaysia there are anecdotes of soliciting mobile phone photographs of nesting hornbills, for a small cash reward: the reward is indeed paid, but metadata (e.g., date, location) are then potentially available to the one receiving the photograph (G.W.H. Davison, pers. obs.).

Climate change is also predicted to impact wildlife movements and their ecology over time. Predictive modeling of climate change impacts on hornbill species in India showed that shifts in their distribution were possible (Sarkar and Talukdar 2023). This could arise due to the changes in the forest phenology when the normal patterns are disrupted. The disruption could affect the hornbills' breeding period. Malaysia is now experiencing changing weather patterns at the local level in recent years (Abdul Rahman 2009). The intensity of El Niño and La Niña events is increasing which has resulted in longer dry seasons (or droughts) and heavier rainfall during monsoonal months in parts of the country (Hashim and Ibrahim 2025). The potential impact of weather disruptions on hornbill ecology in Malaysia remains unclear for the time being, which necessitates long-term monitoring of hornbills in our forests, but may result in scarcer or more unpredictable food sources, and potentially altitudinal shifts.

Birdwatching tourism is a growing industry globally and in Malaysia (Tourism Malaysia 2021). The desire to "tick off" or photograph iconic birds in birdwatching sites has led to undesirable behaviour in the birdwatching and photography communities. The use of playbacks or the creation of bird feeding 'ports' to attract birds is now common practice. Playback is often used to lure birds into the open for better photo opportunities. The Helmeted Hornbill is regarded as a 'star bird'. One incident in Fraser's Hill highlighted the lengths that photographers go to capture the perfect photo of the Helmeted Hornbill pair (Macaranga 2022). Yang *et al.* (2025) have shown that the use of call playback could be fatal to territorial birds, especially during sensitive periods such as breeding.

Another unhealthy practice is hornbill feeding as a tourism activity. In Pangkor Island, several tourism operators have advertised Oriental Pied Hornbill feeding as a tourist attraction (Syamil 2020). Foods provided are sometimes suitable (e.g., banana, papaya) and sometimes not (e.g., bread, buns). For both call playback and feeding, wildlife laws are unable to stop these practices as the hornbills (or any bird species) are not physically harmed, nor are their nesting sites damaged. However, hornbill feeding could potentially lead to human-hornbill conflicts in future, as shown on several occasions in Singapore (Yahya *et al.* 2024).

HORNBILL CONSERVATION IN MALAYSIA

The conservation of Malaysian hornbills is tightly linked to their distribution and dependence on large forest areas (Table 1) with distinctions in their preferred vegetation and elevation (Table 2), and the presence of large trees carrying suitable natural cavities for nesting (Table 4). Breeding cycles show annual but prolonged patterns (Table 3), probably influenced by weather, day length and food availability. Figs, however, are irregular and largely aseasonal sources of food, proving reliable only through their abundance in large forest tracts and with multiple species producing fruit at differing times. These characteristics make figs a keystone resource.

Policy support and species action plans

National and State biodiversity-related policies generally do not contain explicit prescriptions on hornbill conservation. However, national and state-level policies such as the National Policy on Biological Diversity and Sabah Biodiversity Policy, respectively, have outlined several key goals and activities that directly and indirectly impact hornbills and their habitats. At the site level, the Royal Belum Special Area Plan in Peninsular Malaysia has also explicitly outlined hornbills as the protected area's natural asset and recommended regular monitoring of hornbill populations. In Sabah, the state government is developing a Hornbill Action Plan with assistance from local NGOs (Vanar 2023). Regionally, the Helmeted Hornbill species action plan has been developed, but adoption and implementation by range countries were poor (Jain *et al.* 2018).

Legal protection of hornbills

Hornbills are relatively well protected under Malaysia's laws. Hornbills are classified as "Totally Protected" under the Wildlife Conservation Act 2010 [Act 716] in Peninsular Malaysia and the Wildlife Protection Ordinance 1998 in Sarawak. In Sabah they are classified as "Protected" under the Wildlife Conservation Enactment 1997. Under this enactment, hunting is permitted with a license, but no such application has been made to date (Sabah Wildlife Department, pers. comm.). Additionally, the International Trade in Endangered Species Act 2008 [Act 686], which enforces the resolutions of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) decisions, protects hornbill species in Malaysia from being traded.

Site prioritisation for hornbill conservation

The future survival of hornbills in Malaysia depends entirely on the preservation of remaining forest landscapes. The Malaysian Nature Society developed the Important Hornbill Landscape (IHL) concept to help policy and decision-makers and site managers identify and prioritise forest sites for the best chance of survival for hornbills based on four selection criteria. A total of 17 IHLs were identified for Peninsular Malaysia (Yeap *et al.* 2023), and eight in Sarawak (Wee *et al.* 2024). No IHL has been identified for Sabah currently, but several well-known protected/conservation areas, e.g. DaMaI (Danum Valley, Maliau Basin, Imbak Canyon), Tabin and Kinabatangan Wildlife Reserves, and Tawau Hills Park are considered as hornbill strongholds (Koid *et al.* 2021; Nur Syamimi *et al*. 2025).

Use of artificial nest boxes

Artificial nest boxes are an important tool in hornbill conservation, especially for sites where the forest habitat has been fragmented, causing shortages of suitable nest trees and cavities (Kaur *et al.* 2018; Vercoe *et al.* 2021). The Kinabatangan region is a prime example of this situation. Despite supporting high levels of wildlife diversity, including eight hornbill species, the shortage of nesting trees has prevented hornbills from breeding. The use of nest boxes to assist hornbill pairs to breed has shown some success. The Rhinoceros and Bushy-crested Hornbills have used nest boxes and produced chicks (Kaur *et al.* 2018). However, the provision of nest boxes should be carefully considered due to several factors,

e.g. high maintenance cost (manpower and money), competition from other cavity users, poaching pressures in the area etc (Zhang *et al.* 2023). In some cases, hornbill pairs investigated the artificial nest boxes provided but did not attempt to use it thereafter (Lee and Rombang 2011). The preservation of intact forest landscapes should always be treated as the priority prescription as much as possible before attempting to install artificial nest boxes.

Hornbill and forest guardianship by local communities and indigenous peoples

Indigenous and local communities that live near or in forest landscapes where hornbills are recognised as important stakeholders in conserving hornbills and forests, as proven in other countries e.g., India, Thailand, Indonesia (Poonswad *et al.* 2005; Teampanpong *et al.* 2024; Anon. 2026). MNS has engaged with the local Jahai Orang Asli in BTFC and trained them as hornbill guardians (Yeap *et al.* 2021). They have been instrumental in bridging the knowledge gaps on hornbill ecology in BTFC. In Kinabatangan, local communities and NGOs rallied together to provide artificial nest boxes and even repair natural cavities to enable hornbills to breed (Vercoe *et al*. 2021). Additionally, they also monitor hornbill nests and restore degraded habitats.

Restoring degraded lands and forests for hornbills (and other wildlife)

Figs are currently being actively propagated and used as one of the primary plant groups for restoration projects in Sabah (Parry and Cheema 2021). Five species, i.e. *Ficus subcordata*, *F. cucurbitina*, *F. benjamina*, *F. racemosa* and *F. dubia*, were identified for trial planting that would benefit the eight hornbill species and other wildlife found in Tawau Hills Park. In BTFC, Orang Asli Jahai women in Kampung Chuweh have trialled germinating non-fig hornbill food plants, e.g. *Polyalthia* sp., collected from hornbill middens for the possible use of rehabilitating degraded areas in the landscape (The Habitat Foundation 2025).

Communication, education, and public awareness (CEPA)

The appreciation for hornbills in Malaysia is increasing, as seen on various social media platforms. They are also being featured more in locally published children's storybooks. MNS has conducted several school camps in BTFC, reaching more than 500 school kids and educators, to raise awareness about hornbills and forest conservation. In 2025, Malaysia officially adopted 10 November as its National Hornbill Day (Koshy 2025), elevating its status and spurring more CEPA actions. The Rhinoceros Hornbill is also featured on Malaysia's RM5 banknote, which enables every Malaysian to champion hornbill conservation by using it as a CEPA tool.

Acknowledgement: The authors would like to thank the Department of Wildlife and National Parks (PERHILITAN) Peninsular Malaysia, Forestry Department Peninsular Malaysia, and Perak State Parks Corporation for their interest and support for MNS's hornbill conservation works. The Society is also grateful for the opportunity to build a relationship and work together with the Hornbill Guardians from the Kampung Orang Asli Chuweh (Temengor) and Sungai Tiang (Royal Belum). Without their support and donors, hornbill conservation in Malaysia would not have progressed thus far. We also thank Dr Pilai Poonswad and her Thailand Hornbill Project team for their generosity in sharing their field experiences and knowledge, and mentoring the MNS Hornbill Conservation Project.

REFERENCES

Abdul Rahman, H. 2009. Global climate change and its effects on human habitat and environment in Malaysia. *Malaysian Journal of Environmental Management* 10(2): 17–32.

Amar-Singh, H.S.S. 2025. Hornbill predation of bats. *Malaysian Bird Report* 3: 41–43.

Amar-Singh, H.S.S. and Chiu, S.C. 2024. Use of limestone cavities for nesting by the Oriental Pied Hornbill. *Malaysian Bird Report* 3: 10–15.

Andrew, D.J. 1982. Observations on nesting behaviour in the Rhinoceros hornbill, *Buceros rhinoceros*. *Malayan Nature Journal* 35(1&2): 173–177.

Anon. 2016, September 2. Malaysia nabs 12 with over 200 parts of threatened species. *TRAFFIC*. https://www.traffic.org/news/malaysia-nabs-12-with-over-200-parts-of-threatened-species/

Anon. 2021, September 2013. Seizure in Kuala Lumpur International Airport uncovers Southeast Asian live hornbill trade. *TRAFFIC*. https://www.traffic.org/news/seizure-in-kuala-lumpur-international-airport-uncovers-southeast-asian-live-hornbill-trade/

Anon. 2026, April 11. Which tiger reserve in India allows hornbill nest adoption? Answer will surprise you. *The Times of India*. https://timesofindia.indiatimes.com/life-style/travel/things-to-do/which-tiger-reserve-in-india-allows-hornbill-nest-adoption-answer-will-surprise-you/articleshow/130184710.cms

Aquarini, Ishomuddin, Vina Salviana D.S. and Fatchurahman, M. (2022) The social meaning of the *enggang* bird in batik of dayak community of Central Kalimantan, Indonesia. *Journal of Humanities Social Sciences and Education* 9(5): 68–78.

Ardiantiono, Karyadi, Muhammad Isa, Hasibuan, A.K., Kusara, I., Arwin, Ibrahim, Supriadi and Marthy, W. 2020. Hornbill density estimates and fruit availability in a lowland tropical rainforest site of Leuser Landscape, Indonesia: preliminary data towards long-term monitoring. *Hornbill Natural History and Conservation* 1(1): 2–11.

Atikah, S.N., Yahya, M.S., Ong, K.W., Sanusi, R., Norhisham, A.R. and Azhar, B. 2025. Continuous forests and non-IBA forest patches provide a safe haven for the tropical bird community in highly fragmented urban landscapes. *Biodiversity Conservation* 34: 971–986. https://doi.org/10.1007/s10531-024-03004-7

Azhar, B., Lindenmayer, D.B., Wood, J., Fischer, J., Manning, A., McElhinny, C. and Zakaria, M. 2011. The conservation value of oil palm plantation estates, smallholdings and logged peat swamp forest for birds. *Forest Ecology and Management* 262(12): 2306–2315. https://doi.org/10.1016/j.foreco.2011.08.026

Beastall, C., Shepherd, C.R., Hadiprakarsa, Y. and Martyr, D. 2016. Trade in the Helmeted Hornbill *Rhinoplax vigil*: the 'ivory hornbill.' *Bird Conservation International* 26(2): 137–146. https://doi.org/10.1017/S0959270916000010

Beharrell, N. and Ryder, S. 2004. Innovative conservation initiatives: Bai Tu Long Bay, Viet Nam. *Biodiversity* 5(2): 3–11. https://doi.org/10.1080/14888386.2004.9712722

Bennett, E.L., Nyaoi, A. J., and Sompud, J. 1997. Hornbills *Buceros* spp. and culture in northern Borneo: Can they continue to co-exist? *Biological Conservation* 82(1): 41–46. https://doi.org/10.1016/s0006-3207(97)00012-8

BirdLife International. 2026. Species factsheet: Wrinkled Hornbill. https://datazone.birdlife.org/species/factsheet/wrinkled-hornbill-rhabdotorrhinus-corrugatus

Chasen, F.N. 1939. *The Birds of the Malay Peninsula. Volume 4: The Birds of the Low-Country Jungle and Scrub*. London: H. F. & G. Witherby Ltd.

Chew, H.H. and Supari, S. 2000. Observations of Plain-pouched Hornbills *Aceros subruficollis* in Tasek Temengor, Peninsular Malaysia. *Forktail* 16: 65–68.

Chong, J.L., Yeap, C.A., Yong, J.W.H., Kumaran, J.V., Nelson, B.R. and Loh, I.H. 2021. Ethological evidence of adaptive predation of Oriental Pied Hornbill (*Anthracoceros albirostris*) on farmed swiftlet (*Aerodramus* spp.) in Kalabakan, Sabah, Malaysia. *Acta Ecologica Sinica* 42(4): 255–258. https://doi.org/10.1016/j.chnaes.2021.08.007

Chong, M.H.N. 2011. Observations on the breeding biology of Helmeted Hornbill in Pahang, Peninsular Malaysia. *Raffles Bulletin of Zoology Supplement* 24: 163–165.

Corlett, R.T. 1998. Frugivory and seed dispersal by vertebrates in the Oriental (Indomalayan) Region. *Biological Reviews* 73: 413–448. https://doi.org/10.1017/s0006323198005234

Corlett, R.T. 2017. Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. *Global Ecology and Conservation* 11: 1–22. https://doi.org/10.1016/j.gecco.2017.04.007

Datta, A. 1998. Hornbill abundance in unlogged forest, selectively logged forest and a forest plantation in Arunachal Pradesh, India. *Oryx* 32(4): 285–294.
Dahaban, Z. 1994. Ecological effects of selective logging in a lowland dipterocarp forest on avifauna, with special reference to frugivorous birds. Doctoral dissertation. Selangor: Universiti Kebangsaan Malaysia.
Davies, G. 2022. *Wildlife Atlas of Sabah: maps and conservation*. WWF-Malaysia.
Davis, G. and Payne, J. 1982. *A Faunal Survey of Sabah*. WWF-Malaysia.
Harris, J.B.C., Yong, D.L., Sheldon, F.H., Boyce, A.J., Eaton, J.A., Bernard, H., Biun, A. *et al.* 2012. Using diverse data sources to detect elevational range changes of birds on Mount Kinabalu, Malaysian Borneo. *Raffles Bulletin of Zoology* 25: 197-247.
Hashim, M.H. and Ibrahim, M.H. 2025 A review of the impact of El Niño-Southern Oscillation (ENSO) and adaptation strategies on weather and climate in Malaysia. *Asian Journal of Environment, History, and Heritage* 9(2): 59–66.
Hassan, H. and Yatim, S.H. 2003. Sighting of Great Hornbill (*Buceros bicornis*) at Gunung Raya, Pulau Langkawi. *Journal of Wildlife and Parks* 21: 111–112.
Hussin, M.Z. 1994. Ecological effects of selective logging in a lowland dipterocarp forest on avifauna, with special reference to frugivorous birds. Doctoral dissertation. Selangor: Universiti Kebangsaan Malaysia.
Ismail, A., Rahman, F. and Nurul-Huda, M.J. 2015. The use of abandoned clay jars for nesting by Oriental-pied hornbill in Sungai Panjang, Sabak Bernam. *Malayan Nature Journal* 67(1): 42–49.
Jain, A., Lee, J.G.H., Chao, N., Lees, C., Orenstein, R., Strange, B.C., Chng, S.C.L. *et al.* 2018. Helmeted Hornbill (*Rhinoplax vigil*): Status Review, Range-wide Conservation Strategy and Action Plan (2018-2027). IUCN Species Survival Commission Hornbill Specialist Group. https://iucnhornbills.org/wpcontent/uploads/2018/09/HelmetedHornbill_actionplan_final_LR.pdf
Jeyarajasingam, A. 2012. *A Field Guide to the Birds of Peninsular Malaysia and Singapore* (2nd Edition). Oxford: Oxford University Press.
Johns, A.D. 1987. The use of primary and selectively logged rainforest by Malaysian hornbills (Bucerotidae) and implications for their conservation. *Biological Conservation* 40(3): 179–190. https://doi.org/10.1016/0006-3207(87)90084-X
Johns, A.D. 1982. Observations on nesting behaviour in the Rhinoceros hornbill, *Buceros rhinoceros*. *Malayan Nature Journal* 35: 173–177.
Johns, A.D. 1986. Effects of selective logging on the ecological organisation of a peninsular Malaysian rain forest avifauna. *Forktail* 1: 65–79.
Kaur, R., Ong, T., Lim, K.C. and Yeap, C.A. 2011. A survey on mass movements of the Vulnerable Plain-pouched Hornbill in the Belum-Temengor Forest Complex, Peninsular Malaysia. *Raffles Bulletin of Zoology Supplement* 24: 171–176. https://lkcnhm.nus.edu.sg/wpcontent/uploads/sites/10/app/uploads/2017/06/s24rbz171-176.pdf
Kaur, R., Ramli, R. and Ancrenaz, M. 2018. Artificial nest boxes for hornbill conservation: A case study in Kinabatangan, Malaysia. *Sarawak Museum Journal* LXXIX(100): 67–86. https://doi.org/10.61507/smj22-2018-VQ17-05
Kaur, R., Singh, S. and Ahmad, A.H. 2015. 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. *Malayan Nature Journal* 67(2): 240–257.
Kaur, R., Singh, S., Ramli, R., Hassan, H., Majinun, A., Ancrenaz, M., Ratag, M. *et al.* 2018. Observations at a nest of Helmeted Hornbill *Rhinoplax vigil* in Borneo, Malaysia. *Forktail* 34: 68–73.
Kemp, A.1995. *The Hornbills. Bucerotiformes*. Oxford: Oxford University Press.
Kemp, A.C. and Kemp, M.I. 1974. Report on a study of hornbills in Sarawak, with comments on their conservation. Selangor: WWF-Malaysia.
Khusaini, A., Shah, M.K. and Ilias, R. 2015, August 11-13. Population distribution of hornbill species in Peninsular Malaysia based on DWNP Wildlife Inventory Programme. [Paper presentation]. National Hornbill Conference 2015, Miri, Sarawak, Malaysia.
Kinnaird, M.F. and O'Brien, T.G. 2007. *The Ecology and Conservation of Asian Hornbills: Farmers of the Forest*. Chicago: University of Chicago Press.
Kitamura, S. 2011. Frugivory and seed dispersal by hornbills (Bucerotidae) in tropical forests. *Acta Oecologica* 37(6): 531–541. https://doi.org/10.1016/j.actao.2011.01.015

Kitamura, S., Yumoto, T., Poonswad, P., Chuailua, P. and Plongmai, K. 2004. Characteristics of hornbill-dispersed fruits in a tropical seasonal forest in Thailand. *Bird Conservation International* 14(S1): S81–S88. https://doi.org/10.1017/s0959270905000250
Koid, Q.Q., Cheema, S., Wong, C.X., Yu, F.T.Y., Repin, R. and Payne, J. 2021. Observations of hornbills in Tawau Hills Park, Sabah, Malaysia. *Hornbill Natural History & Conservation* 2(1): 3–13.
Koshy, E. 2025, August 9. Malaysia launches first-ever National Hornbill Day. *NST Online*. https://www.nst.com.my/news/nation/2024/11/1132332/malaysia-launches-first-ever-national-hornbill-day
Lakim, M. and Biun, A. 2005. A preliminary survey of hornbills within National Parks of Sabah, Malaysia. In *The Ecology of Hornbills: Reproduction and Populations*, S. Lum and P. Poonswad (eds.), pp. 155–161. Samut Sakhon: Pimdee Karnpim Co., Ltd.
Lambert, F.R. 1989. Fig-eating by birds in a Malaysian lowland rain forest. *Journal of Tropical Ecology* 5(4): 401–412. https://doi.org/10.1017/S0266467400003850
Lambert, F.R. and Collar, N.J. 2002. The future for Sundaic lowland forest birds: long-term effects of commercial logging and fragmentation. *Forktail* 18: 127–146. https://static1.squarespace.com/static/5c1a9e03f407b482a158da87/t/5c1feab00ebbe84faf31fe53/1545595569342/Lambert-Sundaic.pdf
Lambert, F.R. and Marshall, A.G. 1991. Keystone Characteristics of bird-dispersed *Ficus* in a Malaysian lowland rain forest. *Journal of Ecology* 79(3): 793–809. https://doi.org/10.2307/2260668
Lee, D. and Rombang, W. 2011. Home for Sumatran hornbills. *Raffles Bulletin of Zoology Supplement* 24: 167–169. https://lkcnhm.nus.edu.sg/wp-content/uploads/sites/11/app/uploads/2017/06/s24rbz167-169.pdf
Leighton, M. 1982. Fruit resources and patterns of feeding, spacing and grouping among sympatric Bornean hornbills (Bucerotidae). Doctoral dissertation. California: University of California.
Leighton, M. and Leighton, D.R. 1983. Vertebrate responses to fruiting seasonality within a Bornean rain forest. In *Tropical Rain Forests: Ecology and Management*, S.L. Sutton, T.C. Whitmore and A.C. Chadwick. (eds.) Oxford: Blackwell Scientific Publication.
Liang, H., McConkey, K.R. and Lim, J.Y. 2024. From beak to fruit: an Asian hornbill database for frugivory and seed dispersal research. *Global Ecology and Conservation* 51: e02879. https://doi.org/10.1016/j.gecco.2024.e02879
Lim, K.C., Yong, D.L., Lim, G., Chia, A. and Wong, B. 2020. 2019-20 Panti Bird Survey – in Summary. *Malaysian Naturalist* 74(1): 47–64.
Macaranga. 2022, August 16. Stop the playbacks if you love helmeted hornbills. *Macaranga*. https://www.macaranga.org/stop-the-playbacks-if-you-love-helmeted-hornbills/
Madge, S.G. 1969. Notes on the breeding of the Bushy-crested Hornbill *Anorrhinus galeritus*. *Malayan Nature Journal* 23: 1–6.
Madoc, G.C. 1947. *An Introduction to Malayan Birds*. Kuala Lumpur: Malayan Nature Society.
Medway, Lord and Wells, D.R. 1971. Diversity and density of birds and mammals at Kuala Lompat, Pahang. *Malayan Nature Society* 24: 238–247.
Meijaard, E., Sheil, D., Nasi, R., Augeri, D., Rosenbaum, B., Iskandar, D., Setyawati, T. *et al.* 2005. Life after logging: reconciling wildlife conservation and production forestry in Indonesian Borneo. Jawa Barat: Centre for International Forestry Research (CIFOR), Indonesia.
Meredith, M. 1995. A faunal survey of Batang Ai National Park, Sarawak, Malaysia. *Sarawak Museum Journal* XLVIII(69): 133–161.
Mohd Jamil, N., Ismail, A., Zulkifli, S.Z. and Rahman, F. 2015. Population size and density of Southern Pied hornbill (*Anthracoceros albirostris convexus*) in human settlement area in vicinity of Sungai Karang Forest Reserve, Malaysia. *Acta Biologica Malaysiana* 4(1): 26–31.
Mohd-Azlan, J., Philovenny, P., Maiwald, M.J., Chas, N.B.J., Robert, L.A. and Noske, R.A. 2023. Diversity and relative abundance of hornbills in selectively-logged production forests in Central Sarawak, Malaysian Borneo. *Kukila* 24: 1–10.
Mohd-Taib, F.S., David, G., Lee, A., Low, K.H., Lee, K.S., Yusoff, M.F. and Yaacob, A.R. 2019. Checklist of birds in Pulau Pangkor, Perak, Malaysia. *Malaysian Forester* 82(1): 215–224.

Murali, R.S.N. 2020, January 12. Hornbill sighted in Melaka is native species, not a visitor from the east, says exco man. *The Star*. https://www.thestar.com.my/news/nation/2020/01/12/hornbill-sighted-in-melaka-is-native-species-not-a-visitor-from-the-east-says-exco-man
Nair, V. 2019, November 29. Behold, hornbills in TTDI. *The Star*. https://www.thestar.com.my/metro/focus/2017/06/28/spreading-their-wings-in-ttdi-pair-of-hornbills-living-in-taman-rimba-kiara-for-past-10-years/
Noramly, G. 1998. Birding around Datai Bay, Langkawi. *Suara Enggang* May-June 1998: 16-21.
Nur Syamimi, M., Wong, A. and Bansa, L. 2025. Population assessment and conservation insights of Helmeted Hornbill (*Rhinoplax vigil*) in Imbak Canyon Conservation Area, Sabah, Malaysian Borneo. *Malayan Nature Journal* 77: 53–67.
Pan, K.A. 1987a. A study of species composition and behaviour of sympatric hornbills in Besout, Perak. *Journal of Wildlife and Parks* 6&7: 43–52.
Pan, K.A. 1987b. Notes on the breeding behaviour of southern pied hornbill (*Anthracoceros coronatus*) in Peninsular Malaysia. *Journal of Wildlife and Parks* 6&7: 53–57.
Parry, M. and Cheema, S. 2021. Plant4Tawau: hornbill conservation by replanting of *Ficus* in forest tracts of Tawau, South East Sabah. *Hornbill Natural History & Conservation* 2(1): 28–37.
Poonswad, P. 1995. Nest site characteristics of four sympatric species of hornbills in Khao Yai National Park, Thailand. *Ibis* 137(2): 183–191. https://doi.org/10.1111/j.1474-919x.1995.tb03238.x
Poonswad, P., Kemp, A.C. and Strange, M. 2013. *Hornbills of the World: A Photographic Guide*. Singapore: Draco Publishing and Distribution Pte Ltd and Hornbill Research Foundation.
Poonswad, P., Sukkasem, C., Phataramata, S., Hayeemuida, S., Plongmai, K., Chuailua, P., Thiensongrusame, P. and Jirawatkavi, N. 2005. Comparison of cavity modification and community involvement as strategies for hornbill conservation in Thailand. *Biological Conservation* 122(3): 385–393. https://doi.org/10.1016/j.biocon.2004.08.002
Rahman, F., Ismail, A. and Jamil, N.H.M. 2019. Food items and foraging sites of the oriental pied-hornbill (*Anthracoceros albirostris*) during breeding season in Sungai Panjang, Sabak Bernam, Malaysia. *Pertanika Journal of Tropical Agricultural Science* 42(1): 251–259. http://psasir.upm.edu.my/id/eprint/67336/
Rasmussen, P. 2000. A review of the taxonomy and status of the Plain-pouched Hornbill *Aceros subruficollis*. *Forktail* 16: 83–91. https://www.coraciiformestag.com/Research/Hornbill/Rasmussen-Hornbill.pdf
Records Committee, MNS-BCC. 2000. Plain-pouched Hornbill *Aceros subruficollis* – A new species for Malaysia. *Malayan Nature Journal* 54(3): 267–269.
Sarkar, D. and Talukdar, G. 2023. Predicting the impact of future climate changes and range-shifts of Indian hornbills (Family: Bucerotidae). *Ecological Informatics* 74: 101987. https://doi.org/10.1016/j.ecoinf.2023.101987
SFC. 2017. Proceedings of the Sarawak Hornbill Workshop 2012 - Hornbill Conservation: Threats, Gaps & Future Direction. Kuching: Sarawak Forestry Corporation.
Sheldon, F.H., Moyle, R.G. and Kennard, J. 2001. Ornithology of Sabah: History, gazetteer, annotated checklist and bibliography. *Ornithological Monographs* 52: 1–285.
Smythies, B.E. 1999. *The Birds of Borneo* (4th Edition revised by G.W.H. Davison). Kuching: Natural History Publications (Borneo) Sdn. Bhd.
Sodhi, N.S. 2002. A comparison of bird communities of two fragmented and two continuous southeast Asian rainforests. *Biodiversity and Conservation* 11: 1105–1119. https://doi.org/10.1023/A:1015869106512
Styring, A.R., Lomoljo, R.M. and Hussin, M.Z. 2002. Observations of a Bushy-crested Hornbill (*Anorrhinus galeritus*) nest in a west Malaysian forest reserve: insights on feeding behaviour and group size. *Malayan Nature Journal* 56(2): 169–173.
Syamil. 2020, October 6. Hornbill feeding at Pangkor. *Ipoh Echo*. https://www.ipohecho.com.my/2013/10/16/hornbill-feeding-at-pangkor/
Tella, J.L., Fuentes-Sendín, C., Gutiérrez-Expósito, C., Ruiz-Jiménez, G., Sainz-Elipe, R., Sánchez-Prieto, C.B. and Serrano, D. 2025. Bushy-Crested hornbills successfully hunting flying bats in Gomantong Caves, Malaysia. *Ecology and Evolution* 15(7): e71744. https://doi.org/10.1002/ece3.71744
The Figs of Borneo. (n.d.). The Figs of Borneo. http://borneoficus.info
rttttttttt

Teampanpong, J., Da-Ouli, N., Thiensongrusamee, P., Phongkieo, N.T. and Poonswad, P. 2024. Social determinants of success of community-based hornbill conservation in Thailand. *Global Ecology and Conservation* 51: e02883. https://doi.org/10.1016/j.gecco.2024.e02883

Tisen, O.B. and Abang Arabi, A.A. 2015. Voice of the people in conservation: The Piasau Camp Story. Proceedings of the 17th Malaysian Forestry Conference 11-12 November 2014, Kota Kinabalu, pp. 408–412. Kota Kinabalu: Sabah Forestry Department.

Tourism Malaysia. 2021. *Birdwatching Paradise: Malaysia*. Kuala Lumpur: Ministry of Tourism, Arts and Culture Malaysia.

Vercoe, M., Barton, C., Kaur, R., Figueira, R., Macaulay, B., Boyd, M. and Ancrenaz, M. 2021. Artificial nest cavities can sustain populations of hornbills in the degraded forests of Kinabatangan, Borneo. *Oryx* 55(3): 330–331. https://doi.org/10.1017/S003060532100020X

Vanar, M. 2023, March 13. Sabah working on long-term plan for hornbill conservation. *The Star*. https://www.thestar.com.my/news/nation/2023/03/13/sabah-working-on-long-term-plan-for-hornbill-conservation

Viseshakul, N., Charoennitikul, W., Kitamura, S., Kemp, A., Thong-aree, S., Surapunpitak, Y., Poonswad, P. and Ponglikitmongkol, M. 2011. A phylogeny of frugivorous hornbills linked to the evolution of Indian plants within Asian rainforests. *Journal of Evolutionary Biology* 24, 1533–1545. https://academic.oup.com/jeb/article/24/7/1533/7318701

Wee, S.Q., Teo, J.J., Teepol, B., Jelembai, H.N., Au, N.J., Yeap, C.A. and Jain, A. 2024. Identifying Important Hornbill Landscapes in Sarawak, Malaysia. *Global Ecology and Conservation* 50: e02828. https://doi.org/10.1016/j.gecco.2024.e02828

Wee, Y. 2023, June 24. Did the Oriental Pied Hornbills catch a pair of Whiskered Myotis bats? - Bird Ecology Study Group. *Bird Ecology Study Group*. https://besgroup.org/2019/07/06/did-the-oriental-pied-hornbills-caught-two-whiskered-myotis-bats/

Wells, D.R. 1999. *The birds of the Thai-Malay peninsula. Volume One: Non-passerines*. Cambridge: Academic Press.

Wong, B. 2020. Periodic nest observations of the Bushy-crested Hornbill at Panti Bird Sanctuary in 2018 and 2019. *Malaysian Naturalist* 74(1): 73–77.

WWF-Malaysia. 1998. Assessment of wildlife and its management in relation to forestry in the KPKKT concession area, Terengganu. Petaling Jaya: WWF-Malaysia. (Unpublished).

Yahya, Z., Chin, M.Y., Syaddad, A. and Johns, P. 2024. Land use and oriental pied-hornbill occurrence in Singapore. *Global Ecology and Conservation* 54: e03060. https://doi.org/10.1016/j.gecco.2024.e03060

Yang, S., Lu, X., Liu, J., Yu, S., Yang, Z., Zuo, A., Mo, R., Zhu, D., Liu, S. and Duan, Y. 2025. Effects of birdwatching tourism on breeding behaviour and reproductive success of hornbills. *Applied Animal Behaviour Science* 292: 106763. https://doi.org/10.1016/j.applanim.2025.106763

Yeap, C.A. 2025. Hornbill distribution, abundance and resources in the Belum-Temengor Forest Complex in Malaysia. Doctoral dissertation. Serdang: Universiti Putra Malaysia.

Yeap, C.A. 2005. Report on Birds of Langkawi Archipelago. *Malayan Nature Journal* 57(1): 91–143.

Yeap, C.A., Lim, K.C., Noramly, G., Roslan, C., Azam, C. and Marisan, P. 2016. The Malaysian Nature Society Hornbill Conservation Project. *Malayan Nature Journal* 68(4): 149–159.

Yeap, C.A., Louis, D. and Perumal, B. 2023. The Important Hornbill Landscape 2.0 in Peninsular Malaysia: Revised. *Malayan Nature Journal* 75(3): 365–377.

Yeap, C.A., Ong, T., Lim, K.C., Kaur, R. and Rashida, D. 2015. Conserving the globally threatened Plain-pouched Hornbills in the Belum-Temengor Forest Complex, Peninsular Malaysia. *Malayan Nature Journal* 67(2): 144–157.

Yeap, C.A., Perumal, B., Carang, R., Carang, A., Pandak, M., Roslan, D., Mes, H. *et al.* 2021. Can Indigenous Peoples protect hornbills in Peninsular Malaysia? A case study from Belum-Temengor Forest Complex, Perak State, In *Policy Matters. Special Issue on Environmental Defenders*, Ramos *et al.* (eds.), 22 (Vol. II), pp. 46–61. Gland, Switzerland: IUCN.

Yong, D.L. and Low, B.W. 2018. The 125 Best Birdwatching Sites in Southeast Asia. Oxford: John Beaufoy Publishing.

Zhang, L., Ma, X., Chen, Z., Wang, C., Liu, Z., Li, X. and Xing, X. 2023. Negative effects of artificial nest boxes on birds: A review. *Avian Research* 14: 100101. https://doi.org/10.1016/j.avrs.2023.100101