

Helmeted hornbill casque: Is its antiquity, uniqueness, and perceived value leading to the species' extinction?

Pilai Poonswad^{1*}, Bee Choo Strange¹, Sitthichai Jinamoy², Siriwan Nakkuntod², Preeda Poonswad², Sukanya Chaisuriyanun², and Vijak Chimchome^{1,2}

¹Hornbill Research Foundation, c/o Department of Microbiology, Faculty of Science, Mahidol University, Bangkok, Thailand

²Thailand Hornbill Project, c/o Department of Microbiology, Faculty of Science, Mahidol University, Bangkok, Thailand

***Corresponding author:** Pilai Poonswad (pilai.poo@mahidol.ac.th; cc:bcstrange.hrf@gmail.com)

The Helmeted Hornbill *Rhinoplax vigil* is considered to be a sister taxon of the Great Hornbill *Buceros bicornis* and Rhinoceros Hornbill *B. rhinoceros* with a common ancestor among all hornbills, perhaps evolving 56–45 mya (Viseshakul et al., 2011). The present distribution of the Helmeted Hornbill is in the Sunda Region, ranging from southern Myanmar, southern Thailand, and Malay Peninsula to Sumatra and Borneo (Kemp et al., 2023). The Helmeted Hornbill, like most forest hornbills, is omnivorous; however, its diet consists mainly of fruits, and it is the only family of birds that can disperse plants with large seeds (> 25 mm) in the forests of Asia (Kinnaird and O'Brien, 2007; Poonswad et al., 2013b). The male is the sole provider of food when the female (and later chick/s) is incarcerated in the nest cavity. Research by the Thailand Hornbill Project reported that, during 1994–2009 at the Budo Su-ngai-Padi National Park, the study site in southern Thailand, the most important nest tree family was Dipterocarpaceae, primarily the genera *Neobalanocarpus*, *Hopea*, and *Shorea*. These genera accounted for 47.6% of the 189 nest trees of the Helmeted Hornbill and five other sympatric species: (Great Hornbill *B.*

bicornis, Rhinoceros Hornbill *B. rhinoceros*, Wreathed Hornbill *Rhyticeros undulatus*, Bushy-crested Hornbill *Anorrhinus galeritus*, and White-crowned Hornbill *Berenicornis comatus*) occurring in the area (Poonswad et al., 2012). Helmeted Hornbill requires nest cavities with specific characteristics, i.e., protrusions or a platform for the male to land on and feed the female and chicks (Thiensongrusamee et al., 2005). Nest cavities with such features may not be abundant; however, this has not been studied throughout this hornbill's range. Competition for nest cavities is high, especially among the three large-sized hornbill species, and particularly for the Helmeted Hornbill. These requirements pose a challenge to the Helmeted Hornbill reproduction, likely ultimately impacting its long-term population sustainability.

The Helmeted Hornbill is found in lowland tropical rainforests of the Sunda subregion at relatively low densities (Kinnaird and O'Brien, 2007; Poonswad et al., 2013b). Helmeted Hornbill is a large hornbill, measuring 110–127 cm (with 2 additional extra-long central tail feathers of 30–45 cm), with males weighing 3060 g and females weighing 2610–2840 g



Fig. 1: Helmeted Hornbill female (left) and male (right). Art by: Preeda Poonswad

(Poonswad et al., 2013a). Helmeted Hornbill is protected by various national laws in its range countries (Ministry of Natural Resources and Forestry, Indonesia, 2018; Royal Thai Government, 2019) and by CITES.

For Malaysia, the Helmeted Hornbill is provided total protection in Peninsular Malaysia under Wildlife Conservation Act 2010 and Sarawak Wild Life Protection Ordinance 1998, whereas in state of Sabah, while the Helmeted Hornbill is protected under Schedule II of Wildlife Conservation Enactment 1997, it may be hunted but requires a licence. In the past few decades, large numbers of illegally traded Helmeted Hornbill heads, skulls, or bills have been confiscated in Indonesia and China (Collar, 2015). Consequently, the IUCN uplisted the species from Near Threatened to Critically Endangered in 2015. In this article, we examine the structure and properties of the casques, which are in demand for carving jewellery, ornaments, and other decorative objects.



Fig. 2: Rhinoceros Hornbill head and cross-section to depict the hollow casque.

Features of the Helmeted Hornbill bill and casque

The Helmeted Hornbill has a disproportionately large head and wrinkled, swollen skin on the neck that is red in males and greenish-blue to pale blue in females (Fig. 1). It has a solid, approximately rectangular casque above the short, straight, or slightly curved bill; the casque is filled with trabeculae, and the front is made of a thick keratin layer (Matiger Cats, 1961; Surapaneni et al., 2025), whereas its closest relative, the Rhinoceros Hornbill, has a hollow casque and a much longer, down-curved bill (Fig. 2). The Helmeted Hornbill casque is formed on its anterior face by a thickened area of the keratin sheath, the rhamphotheca, coloured yellow due to the application of uropygial oil by the individual bird, whereas the base of the bill and the sides of the casque are red due to a naturally occurring pigment (Delhey et al., 2007).

The rhamphotheca overlying the casque is formed from fine layers, producing striated light and dark bands of carmine-coloured material in which many small granules of dark pigment of various sizes occur (Brown and Moule, 1982). The solid part of the casque resembles ivory but is actually β -keratin which is only found in reptiles and birds (feathers, beak, tarsus, and claws) (Greenwold et al., 2014). In hornbills, β -keratin also occurs in the casque, and it is tougher than the α -keratin that occurs in horn, hair, scales (of pangolins) and claws of mammals (Greenwold et al., 2014; McKittrick et al., 2012). The hardness of the two types of keratins is similar, ~3 Mohs scale, whereas bone hardness is ~5 Mohs scale (Rothschild et al., 2013). Hornbill 'ivory' is also softer than the ivory of elephants (Kinnaird and O'Brien, 2007), which is composed of dentine (www.env.go.jp/nature/kisho/kisei/en/conservation/ivory/about/). The red colour of the casque is possibly derived from carotenoids in the diet; it is a colour signifying auspiciousness and thus is often favoured in Chinese culture (Bai, 2010). These features of the casque and bill are critical to the past and present exploitation of Helmeted Hornbills by people.

Functions of bill and casque

Morphologically, the Helmeted Hornbill's bill is short, pointed, straight, or slightly curved, with dense keratin along the culmen (Matiger Cats, 1961; Surapaneni et al., 2025) making it stronger and more powerful than other hornbills. In addition to feeding like all hornbills, uses of the bill include digging and scrapping inside a nest hole (see below), collecting fruits, hunting, and chiselling wood around the nest entrance, tamping down and smoothing sealing materials around the nest entrance, and chiselling tree bark while foraging. Helmeted Hornbill has never been seen coming down on the ground

to collect mud for sealing material, as Oriental Pied Hornbills often do (pers. obs. at Khao Yai National Park). The weight of the casque makes up more than 10% of the total body weight; thus, it can serve as a hammer for hitting and butting (Matiger Cats, 1961; Surapaneni et al., 2025). The strength and weight of the Helmeted Hornbill's bill and casque give it potential for use in defence. There is an unpublished anecdote of a poacher in Budo Mountain being wounded as he attempted to rob a nest (PP pers. obs.). There is also evidence of the strength and power of this casque, such as a Helmeted Hornbill destroying an artificial nest box (pers. obs. by a villager who was doing the nest watch; the nest box was later removed). Aerial jousting between male Helmeted Hornbills by casque butting and colliding during flight has been described by Cranbrook and Kemp (1995) and Kinnaird et al., (2003). Courtship display by the male also involves casque butting on a branch, wing flapping, and raising the central rectrices of the tail feathers (Chaiyakam P. pers. obs). Helmeted Hornbills are the only Asian hornbills with elongated central rectrices, and we hypothesise that, in flight or even while perching and feeding, these feathers help counterbalance the weight of the bill and casque.

Two recent papers (Surapaneni et al., 2025; Schlindler et al., 2025) on the examination of the Helmeted Hornbill casque specimens using X-ray microtomography and micro-computed tomography (μ CT) scans clearly show that the casque is filled with a network of dense trabecular bone, and that the rostral part of the keratin sheath is thick (~25 mm) and that the craniofacial joint of Helmeted Hornbills has extensive connections between the casque and braincase, thus giving it a lock-and-key fit that helps to restrict and stabilise head movement. Thus, it is clear that among

Asian hornbills, only Helmeted Hornbills use their casques with impact force, and that the thick and dense trabecular bone might act as a shock-absorbing mechanism, as in woodpecker drumming (Matiger Cats, 1961; Yoon & Park, 2011; Schindler *et al.*, 2025; Surapaneni *et al.*, 2025). Conversely, Rhinoceros Hornbills have a longer, curved, more slender, lightweight bill (Lua and Nakkuntod, 1998), not used for digging or excavating, but rather for reaching food and feeding, and for thermoregulation (Slaughter & Poonswad, 2018).

Evidence exists for a thermoregulatory role of enlarged bills and bare skin in various large birds, including the Helmeted Guineafowl *Numida meleagris* (van Niekerk *et al.*, 2022), Toco Toucans *Ramphastos toco* (Chaves *et al.*, 2023), Southern Ground Hornbills *Bucorvus leadbeateri* (van Vuuren *et al.*, 2020) and the Great Hornbill (Slaughter and Poonswad, 2018) among a range of avian taxa. Given the phylogenetically widespread occurrence of heat exchange in the bill and bare skin of birds, such a role is expected but so far unstudied in Helmeted Hornbills. Thermal differences between the red skin of males and the blue skin of females are a potential point of interest, as the same colour range is also found in guineafowl (van Niekerk *et al.*, 2022).

Traditional/prehistoric human use

Hornbills, especially the Helmeted and Rhinoceros Hornbills, are important in the native cultures of Borneo and Sumatra. Traditional beliefs about hornbills were bound up with hunting for meat, feathers, and casques (Harrisson, 1951; 1988). Recently, as traditional beliefs declined, international demand for hornbill casques suddenly and unexpectedly increased (Collar, 2015; Beastall *et al.*, 2016),

as we note below, to international concern over unsustainable hunting and the rapid decline in populations of Helmeted Hornbills throughout their range (Collar, 2015).

Exploitation of hornbills may have begun during the Stone Age, as Harrisson (1999) noted that parts of a Helmeted Hornbill were found in a cave burial. In cave excavations, bones of hornbills have been found, indicating that they were probably hunted (Piper and Lim, 2021; Stimpson, 2016). Therefore, cultural use of hornbills as food is likely to have been longstanding. In Borneo, where traditional beliefs related to the hunting of wildlife have been more thoroughly documented than in Sumatra or the Thai-Malayan Peninsula, a man who successfully took a human head was then entitled to wear the casque or long tail feathers of the Helmeted Hornbill (Hose, 1929). The native communities also used the casque for personal decorations, such as ear pendants and ceremonial sword belts (Sellato, 1992). Other objects made from Helmeted Hornbill casques were toggles for fastening belts and ear plugs that were only worn by tribal elders who had taken the head of a man. An early Ming traveller wrote in 1416 AD that in Sumatra, the casques were used for making hilts and scabbards for swords (Cammann, 1950). In Malaya and Borneo, beyond the Helmeted Hornbill's natural distribution, the casque 'ivory' was used in the belief that it could be used to detect poisons (Cammann, 1950; Ingram, 2015). A similar belief existed in southern Thailand, based on interviews with about 6 local elderly people who mentioned that they wore a piece of casque 'ivory' set in a ring to protect themselves from poison in food (*pers. comm.* to Pilai Poonswad in 1993–1994).

Beside the casque, Helmeted Hornbill feathers, especially the central tail feathers, were

significantly used. A picture of warrior robes made of hornbill feathers and head decorations made of central tail feathers is featured in Harrison (1988). For example, heads and feathers of Helmeted and Rhinoceros Hornbills were worn by dancers at ceremonies, weddings, and when greeting important visitors (Bennett *et al.*, 1997). The demand for such cultural items led to hornbill hunting, and, besides using hornbill parts within the tribe, trading of goods among tribes was also common (Harrison, 1951; Bennett *et al.*, 1997). In those days, hunters traditionally used blowpipes or took nestlings from nest cavities. This practice has now largely ceased, and only older men may still hunt using these traditional methods (Bennett *et al.*, 1997). Overall, although the impact of traditional hunting on the global Helmeted Hornbill population is well documented, it may not have caused local extinction of subpopulations (Bennett *et al.*, 1997). Traditional hunting impacts were probably not as drastic as compared with the commercial trade from outside Borneo. It was estimated by Bennett *et al.*, (1997) that the traditional hunter could only obtain one Helmeted Hornbill from a forest area of about 80 km².

Historical trade

By 700 AD, when commercial trading had become more extensive, Tanjong Datu at the western tip of modern Sarawak was one of the major trading centers in Borneo. Three major avian products being traded were (1) hornbill 'ivory', (2) edible swiftlets' nests, and (3) feathers for jewellery (feathers of the Great Argus were used in the costumes of courtiers and actors, and the Collared Kingfisher's feathers were used on the faces of pendants and hair ornaments) (Harrison, 1999).

Written evidence of the Helmeted Hornbill casque (*ho-ting*) being used in China has been found in records during the Ming dynasty (1368 to 1644 AD) (Kerr, 2013) when the first Sultan of Brunei, Mohammad Shah, sent some as gifts to the Emperor of China in 1371 (Cammann, 1951). The commercial trade of Helmeted Hornbill casque 'ivory' between China and Borneo could be dated back to at least the eleventh century AD during the Southern Song Dynasty (1127 to 1279 AD) (Beavitt, 1992; Kerr, 2013). The name *ho-ting*, meaning 'crane crest' in Chinese, is a misnomer because it is neither from a crane nor its crest. However, the Malay word for both elephant ivory and hornbill casque is *gading*. Ming writers referred to hornbill 'ivory' as *ho-ting*, the misnomer may be because of the similarity in pronunciation (Cammann, 1951).

Through trading during the Ming dynasty, *ho-ting* was imported from Sumatra, Java, southern Borneo (Kalimantan), Malacca (southern Peninsular Malaysia) and Siam (Thailand). The importation continued for about 500 years until almost the end of the Ching Dynasty (1644 to 1912) (Cammann, 1951; Kerr, 2013). The ornamental and art objects produced from Helmeted Hornbill casques in China included items like thumb rings and plume holders for archery, large buckles for belts, and snuff bottles (Fig. 3) and carved hornbill skulls (Cammann, 1951). The hornbill 'ivory' during the Ming dynasty was worth far more than elephant ivory, and, because it was so rare, it led the Chinese people to make fake items (Cammann, 1950). The demand for Helmeted Hornbill 'ivory' in the form of ornamental objects was not just confined to China. In the 19th century, it spread to Europe and Japan (Cammann, 1950). The Chinese craftsmen then started making European-style jewellery for the Europeans. Records of hornbill 'ivory' in southern Burma

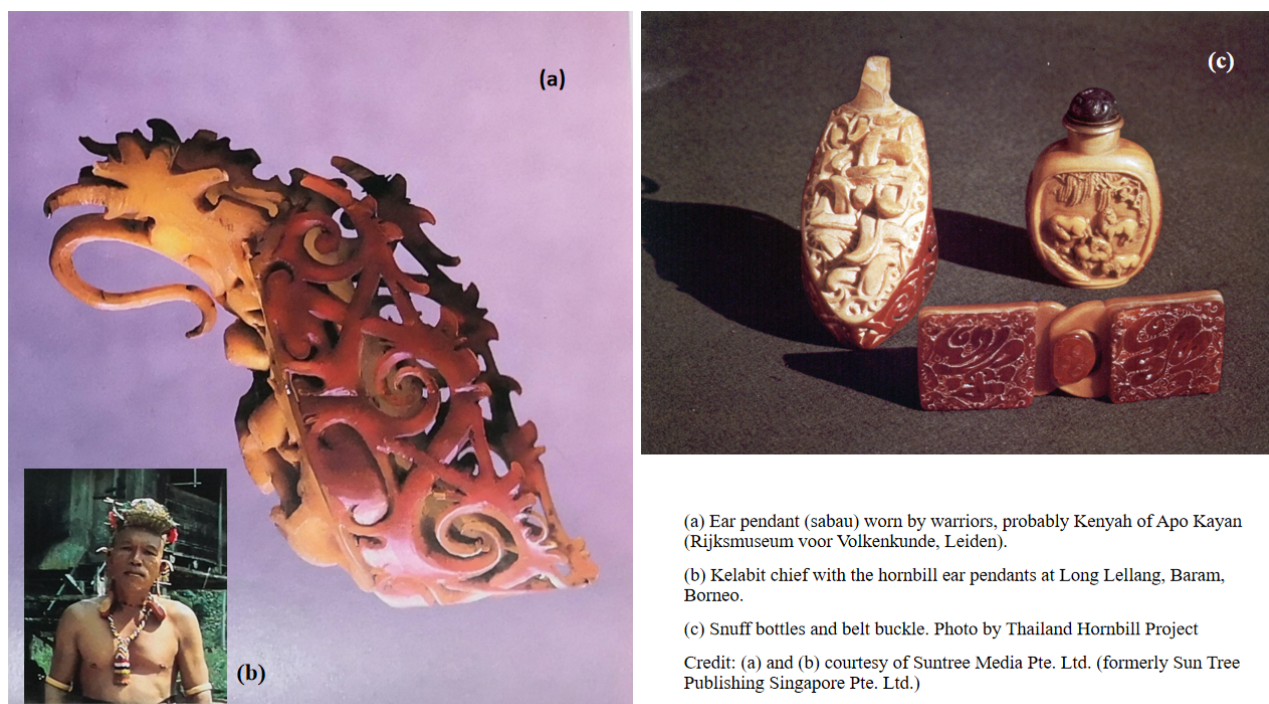


Fig. 3: Artifacts made from the Helmeted Hornbill casques.

from the 19th century indicated that it was exported to Japan (Cammann, 1950). Due to the high demand, the craftsmen later produced replicas of the Helmeted Hornbill skulls, which were made using plastic/polymer (Dietrich, 2015).

Early conservation

Within the natural range of the Helmeted Hornbill, protective legislation was put in place gradually. The Wildlife Commission of Malaya, set up in 1932 to make recommendations on the protection of wildlife, made no specific recommendations for hornbills. They were categorised as game birds (Wildlife Commission of Malaya, 1932). There was a similar early lack of species-specific legislation in Indonesia, Sarawak, and British North Borneo (Sabah), signalling a general lack of concern about their status and the absence of controls on trade.

Subsequently, however, all hornbills were given protection in Peninsular Malaysia under the Protection of Wild Life Act (1972). In Sarawak, all hornbills were listed as totally protected under the Wild Life Protection Ordinance (1998), as they already had been under the previous legislation that the 1998 Ordinance replaced. In Thailand, the Wildlife Preservation and Protection Act, B.E. 2535 (1992) listed 15 animal species, including only three birds, none of which were hornbills. The number of "Conserved Species" was increased to 19 by the Wildlife Conservation and Protection Act, B.E. 2562 (2019), but again not including hornbills. In Indonesia, the basic law on the protection of wildlife is Law No. 5 (1990) on the Conservation of Natural Resources and Ecosystems. Under this law, all Indonesian species on a named list (initially 677 Protected Species) were prohibited from commercial use, while Non-Protected Species could be exploited under a limited set of terms and conditions.

Recent trade and conservation crisis

Between March 2012 and August 2014, a minimum of 2,170 heads/casques of Helmeted Hornbills were smuggled out of Indonesia, destined for China (Beastall *et al.*, 2016). Before 2015, the conservation status of the Helmeted Hornbill was listed as Near Threatened by the IUCN *Red List of Threatened Species*. Triggered by the newly emerging data on confiscations, in September 2015 an urgent meeting was organised at the Singapore Zoo and attended by relevant partners, including government agencies, NGOs, and zoo staff from the range countries, to discuss how to solve the crisis. In late 2015, the IUCN up-listed the status of the Helmeted Hornbill from Near Threatened to Critically Endangered, while the Convention on International Trade in Endangered Species (CITES) had already listed it in its Appendix I as a species prohibited in international trade (Elmanita and Listriani, 2023).

Concurrently with those events, a field study in Thailand by Trisurat *et al.*, (2013) led to the national status of the Helmeted Hornbill being designated as Endangered. More recently, the Thai national authority, the Department of National Parks, Wildlife and Plant Conservation (DNP) realized the issue was extremely urgent and its conservation status was raised from Endangered to Critically Endangered in line with the IUCN global listing. Accordingly, the status of the Helmeted Hornbill was up-listed in 2024 from the 'protected' species category to the ultimate level of 'reserved' species under the Wild Animal Conservation and Protection Act BE 2562 (2019). Animals listed as reserved species receive the highest level of protection in Thailand. In 2018, Indonesia added 227 species to its previous (1990) legislation, bringing the total number to 904 protected species, including 13 species of hornbills, one

of which was the Helmeted Hornbill.

The CITES listing of Helmeted Hornbills, including products, and the tightened national legislation in range nations have led to awareness of the need for improved forensic methods to detect infringements and enforce the laws. Liang *et al.*, (2014) examined ways of detecting real versus fake hornbill 'ivory'. For real material, DNA analysis has been developed by Hatten *et al.*, (2023a, 2023b) and Ouitavon *et al.*, (2022). Wild population monitoring is patchy but includes long-term work at specific sites such as Belum-Temengor in Peninsular Malaysia (Yeap Chin Aik, *pers. comm.*), regional studies (e.g.: Sriprasertsil *et al.*, 2024), and citizen science resources such as eBird (Cornell Laboratory of Ornithology). Such monitoring has led to proposals for enhanced protection of stronghold areas (Jain *et al.*, 2018; Hidayat *et al.*, 2020).

Conclusion

The current situation of the Helmeted Hornbill population is profoundly worrying. This species has rather highly specialised requirements, *i.e.*, very large-diameter trees with specific nest characteristics, as noted previously, and competition for nest cavities among large-sized hornbills is exacerbating the situation. These large hornbills, Great, Helmeted, and Rhinoceros Hornbills produce only one chick per nest per year. For example, during a span of 16 years at Budo-Su-Ngai-Padi National Park (189 km²), a total of 32 chicks fledged from a total 45 sealed nest-years (Avg. 2 chicks/year) for the Helmeted Hornbill. In contrast, the Great Hornbills within the same area yielded a total of 236 chicks from a total of 279 sealed nest-years (Avg. 15 chicks/year), while the Rhinoceros Hornbills produced a total of 126 chicks from

a total of 171 sealed nest-years (Avg. 8 chicks/year) (Poonswad *et al.*, 2012).

The decline of the Helmeted Hornbill is due to demands for the bill and casque as luxury items and is exacerbated by habitat loss. Illegal trading of Helmeted Hornbill casques from their range states, primarily to China, with Lao PDR and Myanmar acting as transiting points, have increased dramatically from 2012 onwards (Beastall *et al.*, 2016; Krishnasamy *et al.*, 2016). There was one record of trade to the United States of America in 2015 (Hadiprakarsa Y. *pers. comm.*). Given the natural distribution of Helmeted Hornbills across Thailand, Malaysia, and much of western Indonesia, the sourcing of hornbill 'ivory' needs to be better known for enforcement purposes. Current information on DNA is applicable at the species level (Hatten *et al.*, 2023a) but are not sufficient to distinguish between products sourced from the Thai-Malayan Peninsula, Sumatra, or Borneo. We urge the government authorities of the range countries to consider these issues as priorities to protect and conserve the Helmeted Hornbill not only for its own genetic lineage but also for healthy forest ecosystems that its existence signifies.

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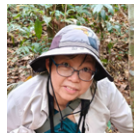
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Pilai Poonswad



Bee Choo Strange



Sitthichai Jinamoy



Siriwan Nakkuntod



Preeda Poonswad



**Sukanya
Chaisuriyanun**



Vijak Chimchome