

NOTEBOOK

Nest predation by Oriental Pied Hornbills *Anthracoceros albirostris* in urban Singapore

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Introduction

With their large size, unique casques and distinctive build, hornbills are among the most iconic families of birds in the Old World tropics (Kinnaird & O'Brien 2008). Oriental Pied Hornbill *Anthracoceros albirostris* (ssp. *convexus*) was first reported in Singapore in the 1850s, but the lack of records thereafter suggests that the species may have been nationally extirpated during the 20th century (Gibson-Hill 1950). The species eventually recolonised Singapore several decades later, with the first recent record on Ubin island in 1994 (Lim 1998, Wells 1999, Lim 2009, Wang & Hails 2007). The species has further benefited from the 'Singapore Hornbill Project' that commenced in the late 2000s, and which involved active reintroduction and the provisioning of nest-boxes (Cremades *et al.* 2011, Cremades & Ng 2012, Teo 2012). Over this period, a (formerly captive) breeding pair from the Jurong Bird Park was directly reintroduced into the Bukit Timah area, while artificial nest-boxes were set up in Ubin to encourage wild birds to use them (Cremades *et al.* 2011, Ng *et al.* 2011). Today, Oriental Pied Hornbill is widely distributed across Singapore, and is common at a number of sites on both Singapore and Ubin islands.

Oriental Pied Hornbill is among the most adaptable of Asia's hornbills and is capable of exploiting a variety of wooded habitats, including secondary forests, coastal forests and forest edges (Wells 1999, Kinnaird & O'Brien 2008, Lim 2009). The species is also able to survive in urban environments given sufficient food and large trees for nesting (Chong 1998, Jamil *et al.* 2015). While largely frugivorous, the species is known to be an opportunistic omnivore (Kinnaird & O'Brien 2008), and has been observed catching animals, particularly insects and small lizards (Teo 2012) and small birds through the predation of nests, in Singapore, Peninsular Malaysia and Thailand (Banwell & Lim 2009, Pierce & Pobprasert 2013, Rahman *et al.* 2019). A study of an Oriental Pied Hornbill pair using an artificial nest-box in Singapore showed that the male brought nearly 6 kg of animals to feed the female and four chicks during the confinement period of 85 days, which

accounted for nearly 12% of their total diet during that period (Cremades & Ng 2012). This confinement period is comparable to the average Oriental Pied Hornbill confinement period of 78.2 ± 5.2 days in natural cavities (Ng *et al.* 2011).

Recently, there has been an increasing number of reported instances of Oriental Pied Hornbills depredating the nests of various bird species in Singapore (Banwell & Lim 2009, Tan & Foo 2019) and even raiding pet bird cages (Lay 2021). We aim to synthesise information on nest predation by Oriental Pied Hornbills in Singapore to determine the ecological implications of predation behaviours on the hornbills and other bird species. To this end, we systematically reviewed the published and grey literature, including citizen science records deposited in online databases. We then analysed the number of nest predation records over time in relation to annual bird census datasets to assess the relationship between the hornbill's population over time and predation frequency.

Methods

Literature review

Primary sources were obtained by ad lib. sampling through authors' opportunistic observations of nest predation records in Singapore (as per Altmann 1974). Sightings of nest predation in Singapore between 1994 and October 2020 were compiled from an online search of Raffles Museum of Biodiversity Research, National University of Singapore (RMBR, now Lee Kong Chian Natural History Museum) and Nature Society (Singapore) databases with the keyword 'Oriental Pied Hornbill'. Additionally, records were compiled from Google searches for internet sources with photographic and/or video evidence, published blog posts such as the Birds Ecology Study Group (BESG), Facebook groups such as Birds, Insects and Creatures of Asia (BICA), Bird Sightings, Singapore Birders and Nature Society (Singapore). Our review was supplemented by a systematic literature review with the following keywords: 'Oriental Pied Hornbill nest predation', '*Anthracoceros albirostris* nest predation', '*Anthracoceros albirostris* predation', 'hornbill nest predation', 'hornbill predation', 'hornbill

cannibalism’ and ‘hornbill carnivore’ in the bibliographic databases (Google Scholar, Web of Science and Science Direct) to identify studies that were relevant.

Statistical analysis

Population data for Oriental Pied Hornbill in Singapore were compiled from the Nature Society (Singapore)’s Annual Bird Census datasets from 1999 to 2020 (Lim 2009, Lim, K.C. *in litt.* 2020). Because the Shapiro-Wilk test for normality showed that our dataset was not normally distributed, in order to assess the relationship between hornbill abundance and the number of records of predation over time,

we carried out a Kendall rank correlation coefficient test. All significance levels were set at $p < 0.05$.

Results

Our review found a total of 18 incidences of nest predation by Oriental Pied Hornbills, 15 of which were successful. These comprised a mix of published records and anecdotal observations by the authors (Appendix 1). Selected photographic records are shown in Plates 1–4. Our systematic literature review of published data did not yield any new evidence of nest predation by Oriental Pied Hornbills.

In all 18 observations, the male hornbill was observed to be the primary predator, while females



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Plate 1. Oriental Pied Hornbill *Anthracoceros albirostris* passing an egg to a female inside an active nest. Unknown location, Singapore, January 2017.

Plate 3. Oriental Pied Hornbill with another bird’s egg. Baker Street, Singapore, April 2020.



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Plate 2. Oriental Pied Hornbill with a sunbird chick between its mandibles. Sungei Buloh Wetland Reserve, Singapore, February 2019.

Plate 4. Oriental Pied Hornbill raiding nest of Tanimbar Corella *Cacatua goffiniana*. Changi Beach Park, Singapore, January 2021.



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were observed in only six incidents and played a supporting role in taking eggs. Thirteen of the 18 records (72%) occurred during the breeding season between December and May. In four cases, the males were seen passing an egg or chick to the female in an active nest. In the cases without a female, males successfully extracted the eggs but were not observed eating them. Eight (44%) predation events occurred in urban areas; the rest were from well-wooded parks and forested nature reserves.

The Singapore-wide annual population count of Oriental Pied Hornbill in the last five years (2016–2020), based on Nature Society Singapore's Annual Bird Census, is 14.6 ± 6.8 individuals. The Kendall-tau correlations showed that annual population counts of Oriental Pied Hornbills and year of observation were positively correlated (Kendall's $\tau = 0.58$, $z = 3.5$, $p < 0.001$). Nest predation count and year of observation were also positively correlated ($\tau = 0.55$, $z = 2.97$, $p = 0.003$). The nest predation counts and population counts were not correlated ($\tau = 0.306$, $z = 1.63$, $p = 0.1029$).

Discussion

Hornbill nest predation records have continued to increase since the first documented record in 2009, 15 years after the species was first reported in the wild in Singapore (Lim 1998). This could be due to an increase in the bird's population in Singapore since its successful recolonisation in the 1990s. There is also the substantial possibility of an observer bias towards this charismatic species as more birdwatchers and wildlife photographers have been active and actively posting information online in the past decade, and perhaps more so over the past five years (83% of incidents were reported between 2016 and 2021). Similarly, reports of nest predation have increased in Peninsular Malaysia recently (Rahman *et al.* 2019).

Although our data show an 83% success rate of nest predation by Oriental Pied Hornbills, this number is likely an overestimate due to observer bias in reporting only successful predation attempts. Asian hornbills such as Rhinoceros Hornbill *Buceros rhinoceros*, White-crowned Hornbill *Berenicornis comatus* and Black Hornbill *A. malayanus* have an average hunting success rate of approximately 5%, despite investing a substantial proportion of their foraging time on hunting (Kinnaird & O'Brien 2008). Similar rates of success may be expected in Oriental Pied Hornbill.

We hypothesise that Oriental Pied Hornbills in urban environments may be (opportunistically) more omnivorous, taking a higher proportion of animal prey than their forest counterparts. This is because hornbill diets are determined by the seasonal availability of fruit, which tends to be

spatiotemporally patchy in urban environments (Kinnaird & O'Brien 2005, Rahman *et al.* 2019). This may help explain why nearly half (44%) of the nest predation accounts occurred in urban areas where fruit resources may be scarce.

In urban habitats, specifically near the Yale-NUS campus and in the Pasir Ris area of Singapore, Oriental Pied Hornbills have been observed moving from tree to tree actively looking for nests (PMJ & TP pers. obs.). These sightings seem to suggest that more open urban habitats may even provide an advantage for these behaviours. By searching through relatively open tree sub-canopies, hornbills in urban areas may be exploiting an unoccupied niche: a behaviour generally not reported for other predatory birds in Singapore. Studies comparing the differences in their foraging methods in various habitats would be beneficial. Additionally, accounts of repeated attempts at nest predation as a pair or group suggest that some of these observations may not be purely opportunistic and that hornbills are hunting cooperatively as well (Appendix 1).

Our observations of male hornbills taking eggs and chicks from the nests of other species to provide an animal protein source to the breeding female and her chicks, mostly during the breeding period between December and May, corroborate findings in the literature that hornbills are known to consume greater amounts of animal matter in the breeding period (Kinnaird & O'Brien 2008, Ng *et al.* 2011). Protein is important for the brooding, growth and fledging of chicks, and consumption of animal protein is known to have a positive correlation with breeding success in hornbills (Poonswad *et al.* 2004, Lamperti *et al.* 2014). Additionally, the provision of food by the male could also be a courtship signal to encourage the female to commence the breeding cycle (Kemp 1995).

Oriental Pied Hornbills are also known to practise infanticide. Females have been observed killing their youngest or weakest chick and feeding it to the others, which could improve their chances of survival (Chan *et al.* 2007, Ng *et al.* 2011). This suggests that hornbills can identify weaker chicks, which may be how the hornbills also identify potential prey. Our study shows that the chicks preyed upon by the hornbills typically belong to smaller bird species such as sunbirds. Although there were two attempts to predate an owl chick and a Crested Goshawk *Accipiter trivirgatus* chick, they were both unsuccessful and no successful predation of eggs or chicks from birds bigger than themselves (such as birds of prey) has been reported so far.

A record of nest predation on Tanimbar Corella *Cacatua goffiniana* (Appendix 1) is notable as it is potentially a double-edged sword: increased predation pressure from the hornbill may serve to

control the population of the non-native Tanimbar Corella in Singapore; however, it may also potentially diminish a globally significant population of the species. Studies have shown that naturalised populations of globally threatened species like *C. goffiniana* in urban areas are of global importance for research and conservation as native island populations of such species dwindle (Gibson & Yong 2017). This event, however, is likely to be a novel occurrence, with only one observation over the past decade. Presently, there is no unequivocal evidence that nest predation by the hornbill has substantially impacted the reproductive success of any bird species in Singapore.

In conclusion, our review shows that nest predation by Oriental Pied Hornbill may have become more common in Singapore. This may be explained by: (1) an increase in the hornbill population; (2) better documentation; or (3) better adaptation by the hornbill towards finding an easy high-protein food source in an urban environment. Eggs or chicks acquired through nest predation may even be an important food source to sustain the urban hornbill populations. Future studies should attempt to determine the ecological impacts of nest predation by Oriental Pied Hornbills through robust and random sampling methods. Studies should also attempt to assess the reproductive success of urban birds in sites where large natural predators such as hornbills are present, compared to those where they are absent.

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Appendix 1. Summary of nest predation accounts by Oriental Pied Hornbill *Anthracoceros albirostris* in Singapore.

No.	Date	Source/ observer	Location	Habitat	Predated species	Number of eggs/ chicks predated	Behaviour
1	March 2009	Banwell & Lim 2009	Changi Village	Urban	Not known	3 chicks	Male observed feeding female and chicks inside the nest
2	2011	Muhammad Fadhl Bin Ahmad	Sungei Buloh Wetland	Wetland reserve	Olive-backed Sunbird <i>Cinnyris jugularis</i>	1 chick	Male raided the nest
3	August 2012	Birds Ecology Study Group (BESG) (Wee 2012)	Pasir Ris Park	Park	Striated Heron <i>Butorides striata</i>	2–3 eggs	Male stole eggs from nest to eat and to feed female
4a	January 2017	BESG (Wee 2017)	Singapore Botanical Garden	Park	Not known	1 egg	Male feeding an egg into an active nest
4b	February 2017	BESG (Lian 2017)	Singapore Botanical Garden	Park	Not known	1 chick	One used a dead chick to lure its own chick out of the nest to take its first flight
5	March 2018	Yong Chee Keita Sin	Sungei Buloh Wetland	Wetland reserve	Brown-throated Sunbird <i>Anthreptes malacensis</i>	1 chick	Male raided the nest and swallowed the chick whole after killing it
6	May 2018	BESG (Teh <i>et al.</i> 2019)	Pasir Ris Park	Park	Spotted Wood-owl <i>Strix seloputo</i>	None	Male seen flying towards an owl chick but was chased away by its parent
7	February 2019	BESG (Yap 2019)	Sungei Buloh Wetland	Wetland reserve	Olive-backed Sunbird	1 chick	Male raided the nest
8	March 2019	Christopher Lee Asplund	Greenwood Crescent Playground	Urban	Black-naped Oriole <i>Oriolus chinensis</i>	1 chick	Male raided the nest
9	May 2019	Tan & Foo 2019	Kent Ridge Campus	Urban	Yellow-vented Bulbul <i>Pycnonotus goiavier</i>	3 chicks	A pair (one male & one female) was seen hopping around the trees before proceeding to raid the nest

No.	Date	Source/ observer	Location	Habitat	Predated species	Number of eggs/ chicks predated	Behaviour
10	May 2019	Tim Plowden	The Edgewater Condo, Pasir Ris	Urban	Black-naped Oriole	2 eggs	On the male's fourth visit, he was accompanied by two others, (one male & one female), who helped to raid the nest
11	July 2019	Tim Plowden	The Edgewater Condo, Pasir Ris	Urban	Oriental Dollarbird <i>Eurystomus orientalis</i>	None	Male made two attempts over two weeks to raid the nest but was forced to retreat by the parents
12	April 2020	Nature Society (Singapore) Facebook group (Leong 2020)	Baker Street	Urban	Not known	1 egg	Male was seen feeding an egg into an active nest
13	September 2020	BICA – Birds, Insects, and Creatures of Asia Facebook group (Terekhova 2020)	Sungei Buloh Wetland	Wetland reserve	Pink-necked Green-pigeon <i>Treron vernalis</i>	2 chicks	Two birds. Only one (a male) was seen eating the two chicks, while the other bird (sex unknown) stood by
14	October 2020	Bruce Swales	Wilby Road	Urban	Unknown	1 chick	Two males and one female raided the nest in a palm tree. One male successfully stole a chick and all three flew off
15	October 2020	Bird Sightings Facebook Group (Tan 2020)	Pasir Ris Park	Park	Unknown	1 chick	A pair was observed and the male had a chick in its beak
16	January 2021	Bird Sightings Facebook Group (Chen 2021)	Changi Beach Park	Park	Tanimbar Corella <i>Cacatua goffiniana</i>	A chick or an egg	The hornbill successfully raided the nest (confirmed by behaviour of the corella), despite attacks by the corella
17	January 2021	Jeremiah Loei	Pasir Ris Park	Park	Crested Goshawk <i>Accipiter trivirgatus</i>	None	Male attempted to raid the nest but was chased away by the goshawk
18	February 2021	Nature Society (Singapore) Facebook Group (Cheng 2021)	Unknown housing estate	Urban	Pigeon sp.	1 chick	A male accompanied by eight others raided a nest and successfully killed one chick, but the chick was too big to be eaten and was left behind