

The status and distribution of the Masked Finfoot *Heliopais personatus*—Asia’s next avian extinction?

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The Masked Finfoot *Heliopais personatus* is among Asia’s most threatened waterbirds. The species formerly ranged widely across north-east India, Bangladesh and South-East Asia, but recent records are few. In this review, we aim to address the gaps in knowledge on the conservation status and ecology of the Masked Finfoot by (1) synthesizing recent information on its occurrence in all range states, (2) re-estimating the global population based on best guesses of national populations, and (3) identifying priority conservation actions. Based on a combination of our survey data (Bangladesh) and best-guess estimates from key sites, we estimate the current population at 108–304 individuals, far lower than the last estimate of 600–1,700 individuals in 2009. Our estimate of population size and rate of decline indicates that Masked Finfoot should be uplisted to Critically Endangered. Masked Finfoot may now breed only in Bangladesh and Cambodia, and there have been no records within the past five years in Malaysia and Thailand, where it once occurred regularly, despite a marked increase in observer effort. Habitat loss and disturbance is the single most important threat to the Masked Finfoot (and many riverine waterbird species), given that low-lying, forested wetlands across South-East Asia are increasingly encroached upon by human activities, or are cleared. There is an urgent need to re-survey areas where it was formerly known, especially in Myanmar. All remaining known breeding populations must be adequately protected or it may become Asia’s next avian extinction.

INTRODUCTION

The Masked Finfoot *Heliopais personatus* is a secretive and poorly known waterbird belonging to a very small yet widely distributed family, the Heliornithidae, and is its only representative in Asia (del Hoyo *et al.* 1996). The species is thinly distributed from north-east India, Bangladesh and Myanmar east to Thailand, Cambodia, Laos and Vietnam, and south to Peninsular Malaysia, Sumatra and Java (Indonesia) (Smythies 1953, Ripley 1961, Milton 1985, Ali & Ripley 1988, Lekagul & Round 1991, Wells 1999, Bezuijen *et al.* 2008, Chowdhury 2012, Mulligan *et al.* 2012, Nurza *et al.* 2017), with its current known strongholds being Bangladesh (Neumann-Denzau *et al.* 2008, Chowdhury 2012, Chowdhury *et al.* 2017) and Cambodia (Mulligan *et al.* 2012, Vann & Mahood 2017). The Masked Finfoot was uplisted from Vulnerable to Endangered in 2009 because rates of population decline were realised to be higher than previously assumed, owing to destruction and disturbance to forested, riverine habitats and, to a lesser extent, hunting and collection of eggs and chicks (Chowdhury *et al.* 2017, BirdLife International 2019). In 2009, BirdLife International (2019) estimated that the global population was 600–1,700 mature individuals. Based on estimated rates of decline (50–79 individuals/10 years or three generations), the present global population may now be substantially lower than previously thought.

Since 2009, there has been no updated estimate of its population and there are no recent assessments of its conservation status (BirdLife International 2019), although the work by Chowdhury *et al.* (2017) and Neumann-Denzau *et al.* (2008) vastly improved understanding of the species’s nesting ecology and habitat requirements, at least in the Sundarbans of Bangladesh. Yet habitat loss continues unabated throughout its distribution, with forested wetlands (including both lowland riverine forests and mangrove forests) in South-East Asia increasingly threatened by unsustainable human use (e.g. fishing, mining) and damming (e.g. Dudgeon 2000, 2005). Recognising the large gaps in knowledge on the status of the Masked Finfoot and the urgent level of conservation concern for the species, we review new and emerging information from across its entire distribution, while aiming to establish a new global population estimate and identifying conservation and research needs. To do so, we (1) compiled and summarised all recent published and unpublished population data on the occurrence of Masked Finfoot, (2) used these to update information on the species’s ecology, movements and population estimates in all range countries, (3) provide an update to the conservation status

of the species based on IUCN Red List criteria, and (4) identify conservation actions needed to avert the imminent extinction of this charismatic waterbird species.

REVIEW OF PRESENT STATUS OF MASKED FINFOOT IN RANGE STATES

Bangladesh

There is limited historical information on the Masked Finfoot in Bangladesh. Presently, the freshwater-dominated zones of the 6,017 km² of mangrove forests in the Sundarbans of south-west Bangladesh are the only known site for the species in the country (Neumann-Denzau *et al.* 2008, Chowdhury *et al.* 2017). It is estimated that the eastern part of the Sundarbans in Bangladesh currently supports between 40 and 80 breeding pairs (SUC pers. obs.), but with a declining population trend. Threats faced by the species in Bangladesh include sea-level rise impacts such as saltwater intrusion in key habitats, leading to a reduced freshwater supply, as well as the collection of eggs and chicks from nests by local fishermen (Chowdhury *et al.* 2017). Recent studies in the Sundarbans show that there has been a shift in habitat preference of the Masked Finfoot. This progressive shift in habitat preference is not only visible in terms of tree species selection for nesting, but also in its overall breeding distribution. There has been a sharp decline of the Masked Finfoot in the coastal part of the Sundarbans concomitant with a shift in nesting habitat towards less saline areas closer to the landward edge of the Sundarbans (Chowdhury *et al.* 2017).

Chowdhury (2012) conducted a semi-structured questionnaire survey targeting local fishermen, forest guards and other natural resource collectors over two months during July and September 2011. Interview questions focused on motivations, methods and occurrences of hunting, poaching, egg and chick collection of the Masked Finfoot, following the guidelines outlined in Newing (2011). Of 68 fishermen interviewed, 38 (56%) indicated that they had captured 16 adults, collected 15 chicks and 4 eggs between 2007 and 2011. Masked Finfoots were captured using two methods: primarily by dazzling the birds using flashlights at night while incubating or roosting (93%); and by chasing them into the mangroves in daytime (one report, 7%). The Masked Finfoot nests were usually discovered by the fishermen during *charpata* fishing (long blocks of fishing nets are attached with wooden poles and affixed along the banks of creeks; fish are trapped on the landward

side of the net with the receding tide) as this method and habitat type used for fishing overlaps with Masked Finfoot nesting or roosting habitat (Chowdhury 2012). This indicates that hunting, egg and chick collection pose substantial threats to the Masked Finfoot in the Sundarbans of Bangladesh.

Cambodia

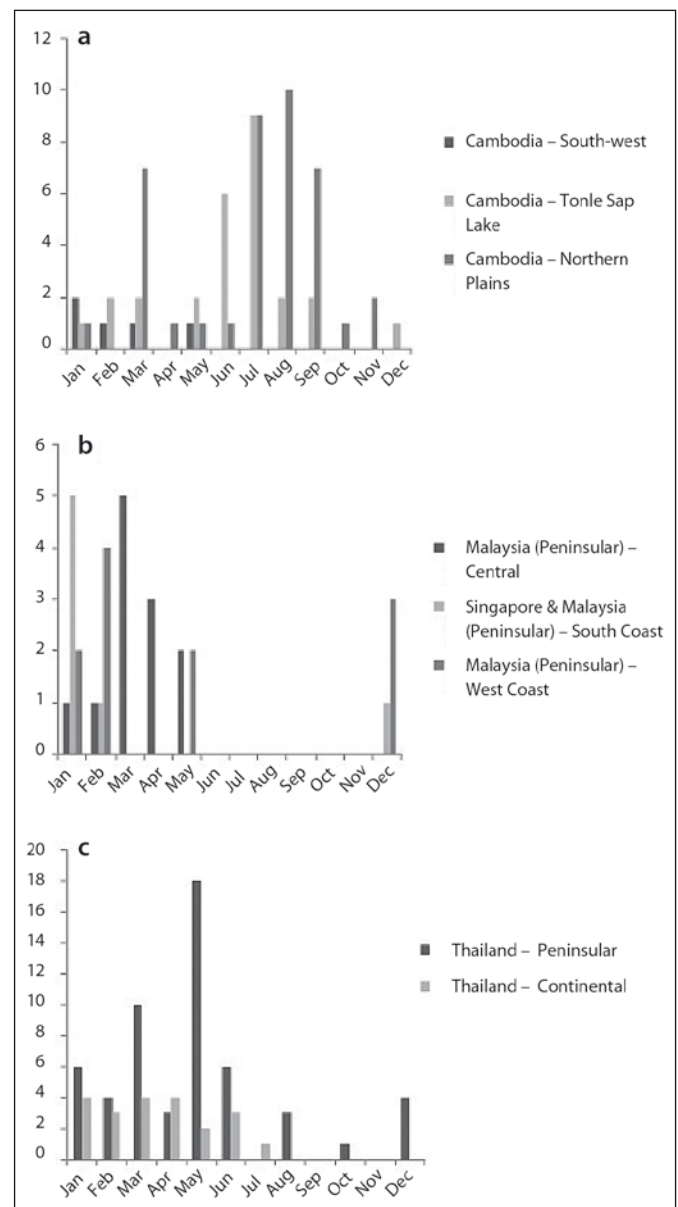
There are few historical records of the Masked Finfoot in Cambodia, demonstrating how poorly known the species was (Thomas & Poole 2003, Bezuijen *et al.* 2008, Goes 2013). Mulligan *et al.* (2012) summarised Masked Finfoot records between 1998 and 2010, and provided details of 31 records based on locally captured birds, direct sightings, camera trap images or vocalisations heard of wild birds. These records were distributed across Cambodia in four main regions (Figure 1a), (1) forested rivers in the Cardamom Mountains in south-west Cambodia, (2) seasonally flooded forest in the Tonle Sap Lake (e.g. Prek Toal Ramsar Site, Boeng Tonle Chmar), (3) forested streams in the Northern Plains (in Chhiep and Kulen Promtep wildlife sanctuaries), and (4) in the north-east on or near tributaries of the Mekong, particularly the Srepok (Timmins & Men 1998, Bezuijen *et al.* 2008, Mulligan *et al.* 2012, Gray *et al.* 2014, Sun Visal & Mahood 2015). Intriguingly, the species has never been detected in the mangrove forests in Koh Kong, adjacent to the Thai border, where there is one historical record.

Post-2010, most records are from Kulen Promtep Wildlife Sanctuary and Prek Toal on the Tonle Sap (Sun Visal & Mahood 2015, Vann & Mahood 2017) (Figure 1a). A survey for Masked Finfoot on forested waterways throughout Kulen Promtep and Chhiep Wildlife Sanctuaries in 2014 and subsequent fieldwork by the Wildlife Conservation Society (WCS) show that the Memey (= Mamay) River system in Kulen Promtep Wildlife Sanctuary is the only known site in the country with a breeding population of Masked Finfoot, likely fewer than 10 pairs (July–October) (unpublished data), although there are occasional records from other months and juveniles have also been observed at other times of year (P. Sithan, *in litt.* 2020). A total of four nests have been found on the Memey River (no more than one per year), from which a total of seven birds were fledged (Harrison & Mao 2017, Vann & Mahood 2017). At the Tonle Sap, Masked Finfoot is still recorded annually in Prek Toal between June and September (1–3 records per year) (Mulligan *et al.* 2012; WCS, unpublished data). The only post-2010 record from the Cardamom Mountains was a pair watched foraging along a forested stream in April 2013 (S. Brook & P. Channa, pers. comm.). Since then, no finfoot-specific surveys have been undertaken in the Cardamoms, camera trapping for Siamese Crocodile *Crocodylus siamensis* (which previously recorded Masked Finfoot) has ceased, and government and NGO staff working in the area are unfamiliar with the species, so the status of the species is uncertain.

The spatial and temporal distribution of records of Masked Finfoot in Cambodia suggests that it moves to forested wetlands during the wet season (June–October) to breed (Figure 1a), and disperses widely during the dry season, although apparent patterns may reflect patterns of observer behaviour. Distances moved by individuals are likely to vary, and some birds are recorded in breeding areas year-round, and therefore may not move at all (WCS, unpublished data).

In Cambodia, the main threats faced by the Masked Finfoot are habitat loss and encroachment due to human activities (e.g. fishing) in lowland wetland areas. At least in the case of the Memey River, riparian (evergreen) forests are subject to intensive illegal logging and encroachment, resulting in habitat degradation and destruction (Mulligan *et al.* 2012). Here, birds are occasionally accidentally captured in fishing gear during the breeding season, despite local rules regulating fishing activities. Local fishermen are encouraged to hand in Masked Finfoots that they capture alive; in 2018 three birds were handed in, of which two adults were released unharmed whilst one recently fledged chick died before it could be released

Figure 1. Monthly records of Masked Finfoot in selected South-East Asian countries since 1937.



(M. Khean pers. comm.). Poisons are used to catch fish and other waterbirds in the Northern Plains, although there are as yet no documented negative impacts on Masked Finfoot.

India

Ripley (1961) considered the Masked Finfoot to be 'resident' in north-east India but there have been no reliable recent Masked Finfoot records from India besides a handful of museum specimens. Verma & Mathur (2006) claimed a record of two Masked Finfoots foraging at a small natural pool located in Nonera village in Bharatpur district, eastern Rajasthan, in 2005. However, this record, far out of range, is doubtful and likely to involve a misidentification (Rahmani *et al.* 2012). Additionally, there are claims of sight records from the Indian Sundarbans and Kondakarla Ava in Andhra Pradesh (Rahmani *et al.* 2012). However, no evidence (i.e. specimens, photos or detailed descriptions) substantiating these claims could be located and the records should be treated as unconfirmed.

The only verified records of Masked Finfoot from India are a number of specimens collected in the early twentieth century from the states of Assam and Arunachal Pradesh (Ali & Ripley 1988, BirdLife International 2001, Rahmani *et al.* 2012). No further evidence of Masked Finfoot's occurrence could be traced

from the mid to late twentieth century from these now relatively well-explored forested rivers and streams (Rahmani *et al.* 2012, P. Jayadevan *in litt.* 2019). However, it is possible that small, and as yet undetected, populations of the species persist in the densely forested swamps and hill tracts in remoter parts of Arunachal Pradesh, Assam and other of India's north-east states, especially along the Dibang and Lohit drainages (e.g. Dibru-Saikhowa). Further surveys will be needed to confirm their presence here.

Indonesia

The Masked Finfoot appears to be a scarce non-breeding visitor to Sumatra, while there is only one record from Java to date: a single individual from well-forested Pulau Rambut off Jakarta in 1984 (Milton 1985, MacKinnon & Phillips 1993). Historical records of the species are mainly from the northern half of Sumatra, with specimens taken from near Medan (Tanjung Beringin, 1898) and in Tapanuli (Muara Tapus, 1939) (Milton 1985). There were also a number of sight records from Way Kambas National Park in Lampung in the 1980s (Milton 1985). The most recent record in Indonesia involved an adult seen and photographed in December 2009 after a lapse of 17 years, at Laut Bangko Lake on the western fringe of the Leuser landscape in Aceh Province in Sumatra (Nurza *et al.* 2017). Prior to this, a record of one adult female and a chick in dense mangroves in Siak Kecil, Riau province, in October 1992 suggested that occasional breeding might have occurred (BirdLife International 2001, Nurza *et al.* 2017). In the absence of recent records in Indonesia, we have excluded Indonesia from our global population estimate.

Laos

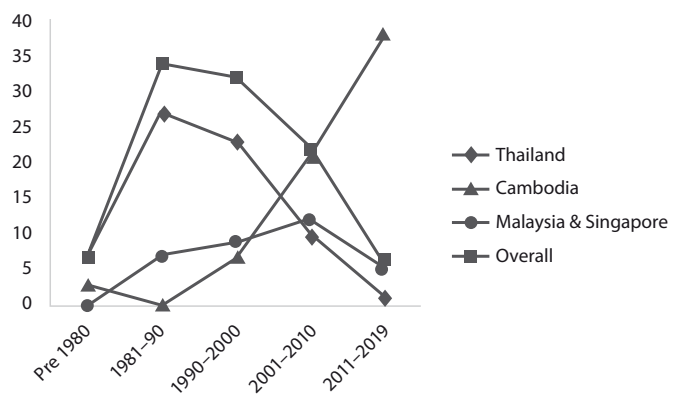
All records of Masked Finfoot are from along lowland forested rivers (100–300 m asl) in southern Laos, particularly in the Xe Pian and Dong Ampham National Biodiversity Conservation Areas (NBCAs) (Duckworth *et al.* 1998). There are also records from Phou Kathong, Dong Kanthung and the Bolaven Southwest proposed NBCAs in Champasak and Attapeu provinces along the border with Cambodia (Thewlis *et al.* 1998, Round 1998, Duckworth *et al.* 1999, BirdLife International 2001). The earliest-known records of the Masked Finfoot in Laos involved a few single birds seen during riverine surveys conducted in the Xe Pian lowlands, particularly along the Xe Pian and Xe Kaman rivers, during March to early May, between 1993 and 1995 (Davidson *et al.* 1997, Bezuijen *et al.* 2008).

In the 1995 Xe Pian surveys, Thewlis *et al.* (1998) noted that at least two birds observed were paired, providing evidence that the species may have bred there. Surveys by Round (1998) at Dong Kanthung detected up to three individuals on the Xe Lamphao on three separate survey days in July 1998, but not in February–March. Post-2000, there have been no further records of the species despite further surveys in the southern lowlands of Laos, including at sites previously known to support the species (e.g. Bezuijen *et al.* 2008). Given the severity of human disturbance and encroachment at Xe Pian, including a hydro-electric dam on the Xe Pian River, and in spite of the large areas of suitable habitat in riverine forest at low elevation, the Masked Finfoot is most likely on the brink of extinction in Laos, if it indeed persists there.

Malaysia

Gibson-Hill (1941) considered the Masked Finfoot to be a widely distributed 'resident' in Peninsular Malaysia, present in both inland waterbodies in the foothills and brackish swamps on the coast (also Chasen 1939). Cairns (1963) reported a number of breeding records in Kedah State (purportedly 15 nests from 1941–1961) although this was never confirmed by other field workers. The available evidence suggests that the Masked Finfoot is a non-breeding visitor to Peninsular Malaysia (Wells 1999, Shepherd 2006, Jeyarajasingham & Pearson 2012, Lim *et al.* 2020); recent records of the species have largely come during the months of October to

Figure 2. Number of records of Masked Finfoot since the early twentieth century, showing a recent decline trend in selected South-East Asian countries from where adequate sightings are available. The increase in sightings in Cambodia is possibly due to an increase in opportunistic and targeted surveys there.



February (Figure 1b). One individual was caught at floodlights during nocturnal surveys at the ridge crest (c.1,100 m) of Fraser's Hill in December 1976, while another was taken from Melaka town in 1964 (Wells 1999), indicating that the species disperses widely. There were regular records of Masked Finfoot on the well-surveyed Tahan River in Taman Negara National Park (Pahang State) up to 2015 (Wells 1999, BirdLife International 2001, Davison *et al.* 2009; also J. Neoh *in litt.* 2020), but not subsequently. In Ulu Muda Forest Reserve (Kedah State) on the border with Thailand, Masked Finfoot has been reported three times from the upper reaches of the densely forested Muda River between 2013 and 2015, but not subsequently (H. Kamaruddin, *in litt.* 2019).

The only other confirmed records of Masked Finfoot in Peninsular Malaysia in the past decade are from Langkawi Island (Kedah State) in coastal mangroves in December (W. Chin *in litt.* 2020), and at Paradise Valley (Ipoh, Perak State), which consists of well-vegetated former mining pools. A single bird was observed at Paradise Valley over four consecutive years from 2012–2015 between the months of February–May, but there had been no sightings thereafter (A. Lee & C. E. Tan *in litt.* 2019). Given the species's retiring habits and the large spread of potentially suitable habitat (rivers in lowland forests, e.g. Krau Wildlife Reserve, Endau-Rompin National Park) that are irregularly visited by casual birdwatchers, it is possible that the species is under-reported in Malaysia. The absence of records from sites where it previously occurred regularly (e.g. Taman Negara; see BirdLife International 2001) and a drop in records over time in the country (Figure 2) reflect broader declines, even at well protected sites. There has only been one record of the Masked Finfoot in Malaysian Borneo (Sarawak), in 2004, in the peat swamps of Maludam National Park (van Balen *et al.* 2013), where it could have occurred as a straggler.

Myanmar

Historically, the Masked Finfoot has been fairly well documented in Myanmar, and reported by various authors to be widely distributed but never common (Hopwood 1921, Chasen 1939, Smythies 1953). Historical records (defined here as pre-1990) were distributed across lowland sites in Kachin State, Sagaing Region, Rakhine State, Ayeyarwady Region, Bago Region, Kayin State, Kayah State and Thanintharyi Region, where it has bred in the past, including the Myeik Archipelago (Hopwood 1921, Chasen 1939, BirdLife International 2001). Some of the most comprehensive documentation of the ecology of the Masked Finfoot, including the earliest known nesting records, came from not far north-west of Yangon on the Myitmaka River in Thayarwaddy District in inundated floodplain forest (Smythies 1953). However, there have been very few records of the species post-2000, although survey

effort has certainly increased at some sites (e.g. Htamanthi, parts of Hukaung, Ayeyarwady Delta), while the floodplain forests of the Myitmaka are now mostly replaced by paddy cultivation.

The most comprehensive information on the recent status of the Masked Finfoot in Myanmar is based on an extensive series of bird surveys carried out in the low-lying riverine wetlands of the Upper Chindwin basin in Kachin and Sagaing from 2003–2005 (Tordoff *et al.* 2007). On three separate, well-vegetated oxbow lakes along the main channel of the Tanai River in the vast Hukaung Valley Wildlife Sanctuary (c.17,300 km²), Tordoff *et al.* (2007) reported small numbers of Masked Finfoots from mid-November to early December, in 2003 and 2004. Further south, two birds were reported in the oxbow lakes along the Nat Kaung near Kamaing Town in October 2005 (Tordoff *et al.* 2007). Given that similarly suitable habitat for the Masked Finfoot, such as well-vegetated oxbow lakes, remains widespread across the Chindwin basin, Tordoff *et al.* (2007) concluded that this region carried high national (and potentially global) significance for the species. Since these surveys, the only recent records from the Hukaung Valley area involved a pair observed on Hin Goh oxbow lake in May 2009 near Deikpha Village, in spite of a regular field presence during the dry season in November–April from 2005 to 2011 (RT pers. obs.). Targeted bird surveys by Hla Naing *et al.* (2015) and extensive camera trapping efforts by WCS staff and forest and community guards since November 2014 have failed to locate any Masked Finfoots, even though the White-winged Duck *Asarcornis scutulata*, a species sharing the same landscape, remains regularly reported on all main streams and oxbow lakes surveyed (RT pers. obs.).

In recent years, the Hukaung Valley has been subjected to rapid encroachment and deforestation (0.274 ± 0.078% per year) due to gold mining and agricultural concessions (Papworth *et al.* 2017, Lee *et al.* 2020). Given the continued and large-scale loss and degradation of forests in the Hukaung Valley (Lee *et al.* 2020), it is likely that the population of Masked Finfoot there has declined substantially. The fate of the finfoots inhabiting the Chindwin and Tanai floodplains remains unknown since the pioneering surveys by Tordoff *et al.* (2007). Unfortunately, political instability in Kachin has curtailed access to much of this part of Myanmar in recent years, impeding urgent work to survey and conserve the species there.

Records of the Masked Finfoot have also been reported from the Htamanthi Wildlife Sanctuary in Sagaing (Istituto Oikos & BANCA 2011), not far south-west of the Hukaung Valley, where similar areas of suitable riverine habitats such as oxbow lakes exist. However, reports of the Masked Finfoot here mainly came from field surveys before 2013 by the Forest Department. Since the WCS established a permanent presence here in 2014, conducting field surveys and camera trapping work along key forested waterways led by WCS staff and forest and community guards, no Masked Finfoots have been reported in spite of daily detections of White-winged Ducks (RT pers. obs.). Furthermore, regular surveys of the many oxbow lakes along the Upper Chindwin from 2015 targeting Baer's Pochard *Aythya baeri* and riverine turtles have yielded no finfoots (RT pers. obs.). Put together, it is likely that the species has suffered a drastic decline there and is now very rare.

Elsewhere in Myanmar, recent visits to the largest remaining areas of mangroves in the Ayeyarwady Delta at Meinmhala Kyun Wildlife Sanctuary and an exploration of the mangrove sites in Tanintharyi Region have resulted in no Masked Finfoot records (Zöckler *et al.* 2019). Given the lack of records from well-known historical localities and sustained habitat destruction in the Hukaung Valley (Papworth *et al.* 2017, Hla Naing *et al.* 2015, Lee *et al.* 2020), it is possible that Myanmar no longer remains as important a stronghold for the species as previously assumed (Tordoff *et al.* 2007, BirdLife International 2019). Nonetheless, field surveys may be useful to re-assess the distribution and status of the species in whatever suitable unsurveyed habitat remains in Myanmar.

Singapore

The Masked Finfoot is a rare non-breeding visitor to Singapore, with all records coming from between November and February (Figure 1b; also Lim 2009, Yong *et al.* 2015, Lim *et al.* 2020). In the past decade, the species has been reported from only two sites, (1) the Central Catchment Nature Reserve (a protected area of lowland secondary forest covering c.2,000 ha) where it was last observed in 2010 (DLY pers. obs., many observers), a male in a forested inlet of the Upper Seletar Reservoir; and (2) the Sungei Buloh Wetland Reserve, a small area of mangrove forests and tidal creeks in north-west Singapore (Lim 2009). It is possible that the species has also occurred on reservoirs in the Western Catchment Area, a fairly extensive landscape dominated by secondary forests, scrub, creeks and reservoirs. However, given that this is a restricted military area, access to conduct surveys here remains difficult.

Thailand

Compared to Myanmar, the majority of records of the Masked Finfoot in Thailand are fairly recent (post-1980), possibly a result of the country receiving far greater coverage by recreational birdwatchers, yet there are comparatively few historical localities (Figure 1c). Sites where the species was reported pre-1980, but where there are no modern records, span the north (Lampang), south-east near the Cambodian border (Chantaburi-Trat), and a handful of sites in the Peninsula (e.g. Ko Phangan, Yala, Pattani) (Robinson & Kloss 1922, Deignan 1963, BirdLife International 2001).

Lekagul & Round (1991) considered the Masked Finfoot to be an 'uncommon passage migrant and winter visitor' in Thailand, but suggested that it 'may perhaps also breed'. Intriguingly, there was an unconfirmed report of a pair with three young in mangroves at Krabi as recently as May 1992 (Round 1992, Wells 1999), although this was never confirmed. Since 1980, at least 61 Masked Finfoot records can be traced from Thailand, most emanating from the mangroves on both coasts of the peninsula, and from inland forest sites in both continental and peninsular Thailand. Nearly half (27 records) come from a single site in the formerly well-watched mangrove-lined creeks of Khao Khanab Nam in Krabi, where 1–3 birds were regularly and repeatedly observed from 1987 to 2001 by birdwatchers guided by one highly skilled local boatman. There have been no records of the Masked Finfoot at Khao Khanab Nam for nearly two decades now (Figure 2), and the most recent records of the species in Thailand were a non-breeding individual present during February–April 2010 at Khao Yai National Park (Round & Sutibut 2010a, 2010b), and one in mangroves in Satun in October 2012 (S. Ardseungnern pers. comm.). The apparent seasonality of sight records (e.g. Lekagul & Round 1991, Wells 1999) and the lack of breeding evidence suggest that the Masked Finfoot is a non-breeding visitor in both continental and peninsular Thailand. Nevertheless, there are records from most months of the year apart from August–September, but only two in the October–November period.

Although there have been no records in Thailand for almost a decade (Figure 2), it is possible that the species may still occur undetected. Further surveys in the country should be focused on historical locations, and perhaps on forested rivers in lowland protected areas of east and south-east Thailand near the Cambodian border (Pang Sida, Thap Lan, Khao Ang Ru Nai); the Western Forest Complex (Thung Yai-Huai Kha Khaeng and adjacent parks and sanctuaries); the still extensive areas of coastal mangroves on the eastern Gulf of Thailand in Trat and Chantaburi provinces; and on both coasts of Peninsular Thailand.

Vietnam

The status of the Masked Finfoot is very poorly known in Vietnam and there are no historical records. It has long been suspected that a breeding population of the Masked Finfoot may be present in south Vietnam, on forested rivers in Kon Cha Rang Nature Reserve and

Yok Don National Park (BirdLife International 2001). A single bird was photographed in Yok Don National Park on the Dak Ken River a few hundred metres from its confluence with the Srepok River on 2–4 June 1997 (Le *et al.* 1997). A male was observed and photographed feeding on the Srepok River on 25 May and again at the same place on 27 May 2002 (JCE pers. obs.), constituting the second record for Yok Don National Park (Eames *et al.* 2003). Additionally, there are two documented sightings in Kon Cha Rang Nature Reserve. A female was present on the Kon River between 10–14 May 1988 (Robson *et al.* 1989), followed by a male observed and photographed by JCE on the Kon River not far from the earlier sighting on 10 May 1999 (JCE pers. obs.)

There have been no subsequent records of the Masked Finfoot in Vietnam. Suitable riverine forest habitat is present at Yok Don National Park along the Srepok River, but which is subject to seasonal variations in water level. Future surveys in Vietnam could target the Srepok and Kon rivers in these two protected areas but it seems unlikely that either location supports a breeding population. Other unsurveyed sites such as the Can Gio Biosphere Reserve on the estuary of the Saigon River may seasonally support the species. Can Gio contains extensive mangrove forest with numerous rivers and creeks (JCE, DLY pers. obs.), a habitat type similar to sites where it has been recorded elsewhere in the region (e.g. Thailand, Malaysia).

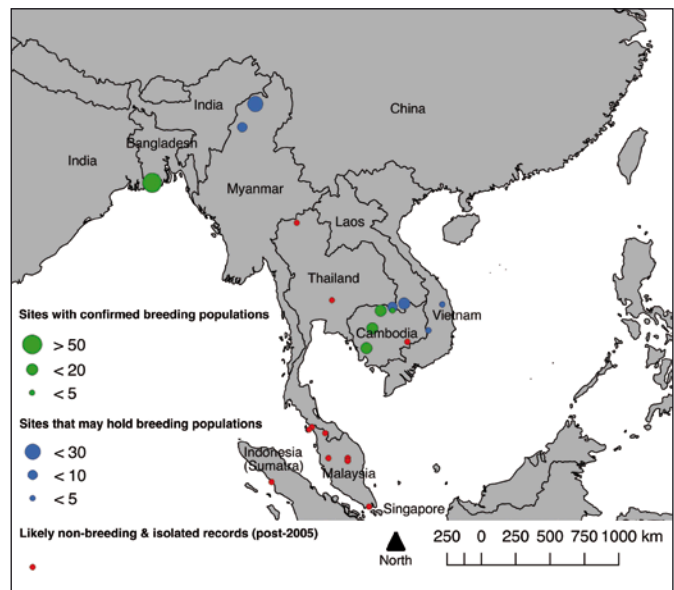
HABITAT AND ECOLOGY

The habitat breadth of the Masked Finfoot is ostensibly wide, and has been described variously by authors to include lowland, forested waterways such as rivers, ponds, oxbow lakes and tidal creeks in mangroves (Ali & Ripley 1988, del Hoyo *et al.* 1996, Wells 1999, BirdLife International 2001), but with some apparent regional variation. However, the available evidence from known nesting records suggests that the species breeds primarily in freshwater forested wetlands, while using most types of forested wetlands with overhanging vegetation during the non-breeding period. In its breeding stronghold in Bangladesh, the resident population of Masked Finfoot occurs primarily in freshwater-dominated, tidal creeks; it avoids saltwater and brackish water zones in the dense mangrove forests of the Sundarbans (Chowdhury 2012). In Cambodia, the species occurs in forested creeks in semi-evergreen forest in the country's northern plains and possibly the Cardamom Mountains, and also in seasonally flooded forest in the floodplain of the Tonle Sap Lake (Mulligan *et al.* 2012). In Myanmar, the species was historically widespread in the Chindwin floodplains in Kachin State and the Myitmaka floodplains in Bago, occurring in oxbow lakes and flooded forest (Smythies 1953, Tordoff *et al.* 2007). Yet further south in the Thai-Malay Peninsula, the species is most often observed along well-forested rivers in tall, lowland evergreen forest (e.g. Taman Negara, Ulu Muda) and mangrove creeks, where it is known to occur only as a non-breeding visitor (Chong 1994, Wells 1999, Lim *et al.* 2020). Its presence across a wide range of coastal and inland wetland habitats appears to be broadly influenced by its need for overhanging vegetation, presumably to rest and to glean for prey items.

SEASONAL MOVEMENTS

In the absence of tracking studies, the movement and dispersal of the Masked Finfoot can only be inferred from the temporal distribution of birdwatching and survey records across different parts of South-East Asia, particularly in Peninsular Malaysia and Singapore (Figure 1b), Thailand (Figure 1c) and, to some extent, Cambodia (Figure 1a, Figure 3). Of over 60 records from Thailand during 1980–2010, March and May held the highest number (Figure 1c), while there was only a single record between September and

Figure 3. Global distribution and present population status of Masked Finfoot based on best-guess estimates at sites where it has been recently recorded (post-2000). Green circles represent sites with recent breeding records (post-2010). Blue circles represent sites that may hold breeding populations. Red dots represent isolated, likely non-breeding records (post-2005).



November, followed again by an increase from December onwards in Peninsular Thailand. In Peninsular Malaysia and Singapore, most records fell within the months December– March (during the wet monsoon there, but the dry, inter-monsoon period in continental South-East Asia) (Figure 1b), while there were no records from June to November. Its local occurrence in atypical finfoot habitats, including in lower montane forest (Fraser's Hill) and isolated tin mining ponds in Peninsular Malaysia, is also suggestive of some level of seasonal, non-breeding dispersal (Wells 1999, Shepherd 2006), although the source populations of these individuals remains undetermined.

In Cambodia, records of the Masked Finfoot are distributed across most months (except October), although the majority of records occur during the wet season between July and September (Figure 1a) (also Mulligan *et al.* 2012, Vann & Mahood 2017). During this period, when birds are on the breeding grounds, there appears to be correspondingly fewer records elsewhere in South-East Asia. Unlike South-East Asia, the population in Bangladesh appears to be resident and sedentary since its feeding behaviour is governed by the diurnal tidal regime and its foraging habitats do not dry out in the winter season.

Seasonal movements (or migration) of the Masked Finfoot is hypothesised to be linked to water levels in seasonal, inland forest habitats, as the species requires adequately high water levels to enable it to forage, including gleaning prey off overhanging riparian vegetation (JCE pers. obs.) Most rivers in the lower Mekong Basin (e.g. Srepok) show major seasonal fluctuations in water level, and recent records in mainland South-East Asia suggest that the Masked Finfoot is rare or absent in the dry season (when river levels are low), but present in the wet season.

DISCUSSION

Conservation status and global population

Currently the Masked Finfoot is listed as Endangered [A2cd + 3cd + 4cd; C2a(i)] (BirdLife International 2019). Based on the records discussed here, we estimate that the global population is 108–304 individuals (Table 1, Figure 3), scattered across a few small

Table 1. Best-guess estimates of the number of mature Masked Finfoot individuals at known sites in all range countries, based on records compiled from 2008 to 2018. Numbers in this table should be treated with caution since information from several sites is based only on anecdotal evidence.

Country	Site	Population estimate		Estimate quality	Notes	Source (in addition to this paper)
		Minimum	Maximum			
Bangladesh	Sundarbans	80	160	Good	Species absent in exclusively brackish parts of western Sundarbans based on field surveys	Chowdhury <i>et al.</i> (2017), SUC pers. obs.
Cambodia	Tonle Sap Lake	4	20	Moderate	Annual records in Prek Toal, similar habitat elsewhere on the lake	Mulligan <i>et al.</i> (2012)
	Kulen Promtep Wildlife Sanctuary	8	20	Moderate	Breeding confirmed	Mulligan <i>et al.</i> (2012)
	Chhep Wildlife Sanctuary	0	4	Moderate	Breeding reported adjacent to Kulen Promtep Wildlife Sanctuary Chhep Wildlife Sanctuary	Mulligan <i>et al.</i> (2012)
	Cardamom Mountains	0	20	Poor	No records since 2013, but negligible survey effort	Mulligan <i>et al.</i> (2012)
India	–	0	4	Poor	No recent records, but north-east, especially Arunachal Pradesh, poorly surveyed	Rahmani <i>et al.</i> (2012)
Indonesia	–	0	0	Poor	No evidence of breeding; riverine lowland forests have declined greatly	This study
Laos	Xe Pian National Biodiversity Conservation Area	2	20	Poor	Large area of suitable habitat remains here, but not well surveyed	Thewlis <i>et al.</i> (1998)
	Dong Kanthung proposed National Biodiversity Conservation Area	2	10	Poor	Large area on Lao–Thai border, but much of it remains poorly surveyed	PDR pers. obs.
Malaysia	Taman Negara	0	0	Moderate	Likely non-breeding only, no records for five years at least	Wells (1999), this study
Myanmar	Htamanthi Wildlife Sanctuary	2	10	Poor	Surveys by Oikos and BANCA have found one record, but suitable habitat remains	This study
	Chindwin Basin (including Tanai River in Hukaung Wildlife Sanctuary)	10	30	Poor	Appeared widely distributed based on surveys by Tordoff <i>et al.</i> (2007); however, large areas of suitable habitat are now destroyed (Papworth <i>et al.</i> 2017, Lee <i>et al.</i> 2020; RT, pers. obs. 2020)	Tordoff <i>et al.</i> (2007)
Singapore	–	0	0	Good	No evidence of breeding	Lim (2009)
Thailand	–	0	0	Moderate	No records despite extensive observer effort; no past evidence of breeding	Lekagul & Round (1991)
Vietnam	Yok Don National Park	0	4	Poor	Large areas of the park remain poorly surveyed	JCE pers. obs.
	Kon Cha Rang Nature Reserve	0	2	Poor	Large areas of the reserve remain poorly surveyed	JCE pers. obs.
Total population		108	304			

subpopulations. This qualifies the species for ‘Critically Endangered’ under criterion C1 on the basis of a small population size (<250 individuals) and a >25% decline over at least one generation/10.4 years (IUCN Red List 2020). Quantifying the rate of decline is challenging given patchy data, but the number of sightings has declined substantially in Malaysia and Thailand despite high and increasing observer effort there (Figure 2), whilst there have been no records from any site in Myanmar and Indonesia for over a decade. In Peninsular Malaysia, it has not been reliably recorded for nearly a decade at the only hitherto regular site, Taman Negara, and the same applies for Krabi, Thailand, another site formerly heavily visited by birdwatchers. The increase in the frequency of sightings in Cambodia is likely an artifact of an increase in survey effort at the only site known to have a breeding population, but is unlikely to reflect an actual increase in the overall population.

In Bangladesh, where the species is best surveyed and studied across its range, there has been a 36% decline in the number of nests in only seven years of surveys carried out in the same area applying the same survey methods (Chowdhury *et al.* 2017). If this rate of decline is projected over three generations (31.2 years), then the present Masked Finfoot population in Bangladesh’s Sundarbans is a product of declines of more than 80% since 1988, again meeting the Red List thresholds for ‘Critically Endangered’ under the population size reduction criteria (A4) and (A2) because the drivers of decline are clearly not easily reversible. If indeed this rate of decline is considered representative of the global population, or if breeding populations outside of Bangladesh are thought to have declined at similar or higher rates to those in Bangladesh (which seems reasonable based on data presented here), then the species should be uplisted to Critically Endangered. Based on standardised

field surveys, the Bangladeshi population was estimated to be 80–160 mature individuals (40–80 breeding pairs) (SUC pers. obs.), demonstrating the overwhelming importance of this population at the global level. In the absence of recent data from Myanmar, where considerable habitat destruction has taken place in the last decade (Papworth *et al.* 2017, Lee *et al.* 2020), an obvious priority is to re-assess sites in the country where the Masked Finfoot has been historically detected.

Our new estimate of its global population, drawing from recent survey data (e.g. Chowdhury *et al.* 2017) and the literature, suggests that the Masked Finfoot may have a far smaller population (and spread of recent records) than other threatened waterbirds sharing similar habitat needs, such as the White-winged Duck. The small size of remaining populations scattered over a vast geographic area (Figure 3) of this low density species in the face of continuing threats suggests that the Masked Finfoot is also highly vulnerable to Allee effects that could further accelerate future decline.

Key knowledge gaps

Targeted studies on the nesting ecology of the Masked Finfoot were recently carried out in its known strongholds in Bangladesh (Chowdhury *et al.* 2017) and Cambodia (Mulligan *et al.* 2012, Harrison & Mao 2017). However, the Masked Finfoot is still essentially one of tropical Asia’s least known waterbirds and there remain large gaps in knowledge of its distribution and its seasonal movements, especially in South-East Asia. Therefore, further studies are needed to better understand its breeding ecology, ranging behaviour, the role of sexes in relation to nest-building to chick rearing, and juvenile dispersal (Chowdhury *et al.* 2018). Knowledge of the ecology of the closely related African Finfoot

Plate 1. Individual differences in facial markings of four adult Masked Finfoots *Heliopais personatus* (a-c: male; d: female). Apart from the varying width and length of the white stripe on the side of the neck, the shape and size of the yellow horn at the base of the bill are also different in different individuals. The fleshy knob above the base of the bill may be present throughout the year (not only during breeding season) and occurs in both males and females, but is visibly shorter in the female. All images taken by SAYAM U. CHOWDHURY.



Podica senegalensis and the Neotropical Sungrebe *Heliornis fulica* may provide useful insights for similar studies in this region.

Long-term studies are also needed to better understand the impact of climate change on its habitat at globally important sites such as the Sundarbans where sea level rise and salt-water intrusion can pose a potential threat to Masked Finfoot habitat (Chowdhury *et al.* 2017). Further surveys are needed in order to identify hotspots within the Sundarbans, where protection measures might be strengthened, and assess the current status of hunting and collection of eggs and chicks by local fishermen. This should be complemented by targeted (and appropriately timed) surveys in mainland South-East Asia to clarify its population status (BirdLife International 2019). However, the difficulty of accessing key wetland habitat for surveys is likely to pose a logistical challenge to surveys in much of its distribution, as is the overall scarcity of the species. Another conservation issue of concern for the Masked Finfoot is the absence of captive populations. Indeed, none of the finfoot species has been kept in captivity (T. Bouttle, *in litt.* 2014). As such, there is neither a captive insurance population nor is there accumulated knowledge or experience in *ex situ* management or captive breeding of the species.

Survey techniques

In order to better understand population density and trends, nesting surveys should be carried out at all known sites in Bangladesh and Cambodia during the known breeding season months of May–September. Marking individual birds (e.g. colour flag, neck collar) at sites where the Masked Finfoot is seen regularly (e.g. Sundarbans) may reveal new knowledge on its ecology. However, it is also possible to identify Masked Finfoot adults using photographs, as each individual evidently shows unique facial markings (Plate 1). This new knowledge could be used to count individuals, as well as

apply a capture–recapture sampling framework (MacKenzie *et al.* 2006, Royle *et al.* 2013) to improve estimates of the Masked Finfoot population, especially in Bangladesh. A photographic, capture–recapture-based sampling approach is a relatively non-invasive and widely accepted method already used with a broad range of species to determine population size (Sutherland 2006, Speed *et al.* 2007, Royle *et al.* 2013). Since little information on the moult of the Masked Finfoot is known (BirdLife International 2001), applying this sampling technique during a single season could easily help fill knowledge gaps.

Moreover, satellite telemetry technology could be used to understand local movement in the Sundarbans and seasonal movements in South-East Asia, obvious limitations notwithstanding (e.g. limited solar-powered battery recharge capacity and fewer fixes inside dense forest).

Conservation challenges and recommendations

The Masked Finfoot depends on low-lying, undisturbed areas of forested wetlands, especially river channels with formerly little or no human activity. Such wetlands in Myanmar, Laos and Cambodia are rapidly being converted for agriculture or encroached upon by people such as fishermen and hunters. For example, many oxbow lakes in Myanmar are now under extensive lease programmes for fisheries (Tezzo *et al.* 2017). Additionally, low-lying riverine wetlands are becoming increasingly scarce due to the construction of impoundments and hydroelectric dams, which may potentially impact large areas of core finfoot habitat in South-East Asia, especially in the Mekong tributaries in Laos, Vietnam and Cambodia (e.g. Sesan and Srepok Rivers). Securing the remaining populations in South-East Asia would demand both political and community efforts to secure the conservation of existing areas of

low-lying forested wetlands, particular those in Cambodia and northern Myanmar.

At present, the two known breeding populations of the Masked Finfoot occur in protected areas (Mulligan *et al.* 2012, Chowdhury *et al.* 2017). However, even in protected areas, hunting and collection of eggs and chicks, the clearance of forested riverine vegetation (e.g. in Cambodia) and the accidental entanglement of birds in (extensively available) mono-filament fishing nets and the use of poisons during fishing (e.g. in Sundarbans, Bangladesh) pose serious threats for the species. Capacity and resources available to site managers to enforce regulations on the harvest of natural resources are often limited. Additionally, it appears that local people usually discover Masked Finfoot nests during fishing or other activities (Tordoff *et al.* 2007, Bezuijen *et al.* 2008, Harrison & Mao 2017; SUC pers. obs.). In order to address this problem, managers of protected wetland sites should consider granting limited or no access to key Masked Finfoot sites during breeding seasons, or temporarily restrict use of mono-filament gillnets. Additionally, large-scale education and outreach campaigns on the global importance of Masked Finfoot and forested wetland habitats targeting local communities may help minimise opportunistic hunting and egg collection or accidental catch. The detailed conservation and research recommendations already outlined in BirdLife International (2001), which were scarcely implemented in the last two decades, remain fully relevant in the present day. Conservation and management interventions, including national action plans for important countries, are urgently needed in order to prevent further population decline and extinction of the Masked Finfoot.

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