The specter of empty countrysides and wetlands—Impact of hunting take on birds in Indo-Burma

Ding Li Yong1 | Anuj Jain1 | Sayam U. Chowdhury2 | Emily Denstedt3 | Kongsy Khammavong3 | Phonesavanh Milavong3 | Thiri Dae We Aung4 | Ei Thinzar Aung4 | Ayuwat Jearwattanakanok5 | Wich’yanan Limparungpatthanakij5 | Rongrong Angkaew6 | Khwankhao Sinhaseni5 | Trong Trai Le7 | Hoai Bao Nguyen8 | Punleu Tang9 | Porchhay Taing9 | Victoria R. Jones10 | Bou Vorsak9

1BirdLife International (Asia), Tanglin International Centre, Singapore
2Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge, UK
3Wildlife Conservation Society Lao PDR, Vientiane, Lao PDR
4Biodiversity and Nature Conservation Association, Yangon, Myanmar
5Bird Conservation Society of Thailand, Bangkok, Thailand
6Conservation Ecology Program, King Mongkut’s University of Technology Thonburi, Bangkok, Thailand
7Viet Nature Conservation Centre, Hanoi, Vietnam
8Vietnam National University, Ecology and Evolutionary Biology Department, University of Science, Ho Chi Minh City, Vietnam
9BirdLife International Cambodia Programme, Phnom Penh, Cambodia
10BirdLife International, The David Attenborough Building, Cambridge, UK

Abstract
Hunting for the wild meat trade, medicines and other human uses has decimated Indo-Burma’s vertebrate biota and has led to widespread defaunation. Yet, there is surprisingly little data on how hunting impacts wild bird assemblages in different landscapes here. Based on concurrent snapshot surveys of bird hunting, food markets and hunting attitudes across six Indo-Burma countries, we found that hunting threatens species not only in forested landscapes but also wetlands and farmlands such as orchards and paddy fields—ecosystems overlooked by past studies, with at least 47 species associated with wetlands and agricultural lands identified from market surveys across the region. High rates of mortality are suffered when hunting tools such as nets are used to exclude perceived bird pests in both aquaculture and agricultural landscapes, with over 300 individual carcasses of at least 29 identifiable species detected in one aquaculture landscape sampled in Thailand. We warn that the potentially unsustainable trapping of species for consumption and trade in Indo-Burma, coupled with high incidental mortalities, could decimate the populations of erstwhile common and/or legally unprotected species. There is an urgent need for stronger regulatory oversight on the hunting take of wild birds and the use of hunting tools such as nets. Alongside this, conservation practitioners need to better engage with rural communities to address unsustainable hunting practices, especially outside of protected areas.

Keywords
bird, defaunation, Indo-Burma, wild meat
1 | INTRODUCTION

The hunting of wildlife is a leading driver of biodiversity loss in the world’s tropics (Symes et al., 2018; Benítez-López et al., 2019), especially in Southeast Asia (Banjade et al., 2020; Corlett, 2007; Duckworth et al., 2012; Harrison, 2011; Harrison et al., 2016). Five countries of mainland Southeast Asia (i.e., Cambodia, Lao PDR, Myanmar, Thailand, Vietnam) and adjoining parts of southwest China, Bangladesh and northeast India (defined variously as Indo-Burma, Tordoff et al., 2012; CEPF, 2020) form among the world’s hottest spots for biodiversity (Corlett, 2019; Duckworth et al., 2012; Sodhi et al., 2004; Tordoff et al., 2012). Alongside widespread habitat conversion and loss due to land-use change (Hughes et al., 2017; Wilcove et al., 2013), Indo-Burma’s biodiversity is being impacted by unsustainable levels of wildlife exploitation which has decimated populations of several bird and mammal species and pushed several to the brink of extinction (Bennett et al., 1997; Corlett, 2007; Duckworth et al., 1999; Gray et al., 2018; 2021; Harrison et al., 2016). Indeed, overhunting is considered a more immediate threat to the region’s vertebrate biota than deforestation and logging (Duckworth et al., 2012; Tilker et al., 2019).

Present evidence from Indo-Burma continues to demonstrate the immense scale of wildlife harvest for trade (Banjade et al., 2020; Dalvi et al., 2013; Duckworth et al., 2012), as well as the roles played by the (1) increased availability of hunting tools such as snares, decoys, guns, and nets (Gray et al., 2018; Harrison et al., 2016; Pruvot et al., 2019), (2) increasing accessibility of sites to hunters (Robinson & Bennett, 2000), (3) socioeconomic forces that drive hunting (Chang et al., 2017, 2019; Liang et al., 2013), and (4) increased pressures on wildlife and other natural resources owing to compromised livelihoods in the wake of the COVID-19 pandemic (Buckley, 2020; Wildlife Conservation Society, 2020). Furthermore, rural communities and ethnic minorities have traditionally harvested wildlife for their protein needs and livelihoods in many parts of Southeast Asia (Johnson et al., 2003; Zack, 2018), adding additional layers of complexity to efforts to address unsustainable wildlife hunting. Today, many forested landscapes in Indo-Burma, including protected areas, support diminished vertebrate densities, with assemblages of larger-bodied species being depauperate as a legacy of past hunting (Corlett, 2007; Harrison, 2011; Symes et al., 2018). Over time, the expected longer-term ecological impact of defaunation is not only limited to population (and biomass) declines (Galetti et al., 2017), there are also significant repercussions on ecosystem functioning (Galetti & Dirzo, 2013) ranging from reduced seedling recruitment (Wright et al., 2007) to collapses in species networks (Marthy & Farine, 2018) and declines in overall carbon sequestration (Chanthorn et al., 2019), while the risks for zoonotic disease transmission are elevated (Gilbert et al., 2012; Pruvot et al., 2019).

Studies of wildlife hunting in Indo-Burma has largely focused on mammals (Corlett, 2007; Steinmetz et al., 2014) and flagship, large-bodied forest birds such as hornbills and pheasants (e.g., Bennett et al., 1997; Chanthorn et al., 2019; Liang & Zhang, 2011). However, there are considerable knowledge gaps in the magnitude at which bird species are affected by hunting in Southeast Asia despite substantial effort to understand the trade in pet birds (e.g., Harris et al., 2017; Marshall et al., 2020), bird-derived ornamental products (e.g., hornbill casques) (Jain et al., 2019) and wild birds for religious releases (Gilbert et al., 2012; McClure, 1998). There are surprisingly few empirical data on how hunting of birds for wild meat, medicines, recreation, and other uses may impact common species in wetlands, cultivated landscapes such as paddy fields which cover vast tracts of the region (Frank & Wilcove, 2019; Hanks, 1992; Xiao et al., 2006), and landscapes outside of protected areas (PAs). Data on the hunting of birds elsewhere in the world, such as the Mediterranean Basin has shown that an estimated 11–36 million individuals are killed/taken illegally in that region every year (Brochet et al., 2016). Here, we draw attention to a simmering conservation crisis affecting wild bird populations across Indo-Burma. In Indo-Burma, hunting and associated forms of indirect take may be taking place at a scale larger than in many regions worldwide, including the Mediterranean and the Middle East, where considerable data already exists (e.g., Brochet et al., 2016). Our results draw from the published literature and recently concluded fieldwork in six countries (i.e., Bangladesh, Cambodia, Lao PDR, Myanmar, Thailand, and Vietnam), and show that the threat and impacts posed by hunting to wild bird populations in the Southeast Asia region needs to be better quantified, alongside urgent action needed to address it.

2 | SCALE OF DEFAUNATION SPANS NATURAL AND ANTHROPOGENIC LANDSCAPES

It is well known that wild birds are widely hunted across Indo-Burma for human consumption and various other uses such as medicines (Evans et al., 2000; Liang et al., 2013; Srikosamatara et al., 1992). Thus far, studies assessing wildlife hunting and the wild meat trade have focused on particular forest taxa such as gamebirds, pigeons (e.g., Treron sp., Ducula sp.), and hornbills (Bhupathy et al., 2013; Liang & Zhang, 2011; Rao et al., 2005), as well as migratory species such as shorebirds (Gallo-Cajiao
et al., 2020), Yellow-breasted Bunting *Emberiza aureola* (Heim et al., 2021), and Amur Falcon *Falco amurensis* (Aiyadurai & Banerjee, 2019; Dalvi et al., 2013). Indeed, the extirpation of the Vietnamese Pheasant *Lophura edwardsi* and the drastic decline of the Crested Argus *Rheinarta ocellata* and several hornbills, among the region’s most charismatic species, may be the outcome of indiscriminate trapping at large scales (BirdLife International, 2021; Eames & Mahood, 2017; Liang et al., 2018), facilitated by the availability of new hunting tools and techniques (Chang et al., 2017; Gray et al., 2018).

Recent surveys (e.g., Nguyen et al., 2020; Xayyasith et al., 2020) and our data drawing from a combination of field surveys and interviews with local people, show that the hunting of birds for wild meat remains widespread in Indo-Burma and its magnitude is likely severely underestimated, impacting a far wider suite of species and ecosystems than previously documented (see Table S1 for list of species reported in market surveys). For example, Xayyasith et al. (2020) recorded 1020 individuals of at least 84 species, representing 30 bird families traded in eight markets sampled in central Laos. Recent studies have also observed hunting and trapping activities in wetlands ranging from freshwater inland lakes to coastal mudflats and aquaculture ponds in Bangladesh, Cambodia, Myanmar, and Vietnam (see Figure 1; also Aung et al., 2016; Chowdhury, 2010; Ha & Phan, 2016; Nguyen et al., 2020; Zöckler et al., 2010), but which have not been covered in past studies of wildlife harvest in the region.

The suspected decline of familiar farmland species formerly common in paddy fields (e.g., watercock *Gallicrex cinerea*, considered as a nationally near threatened in Thailand; Bird Conservation Society of Thailand, 2020) and elsewhere across Indo-Burma is most likely a consequence of (undetected) unsustainable take in farming

![FIGURE 1](image-url)  
(a) Decoys shaped like watercock being used for trapping birds in a Thai paddy field. (b) Forest birds included various (plucked) passerine birds on sale in an evening market in December 2019 in Lao PDR. (c) Mist nets used to trap birds at the edge of a paddy field in northern Thailand. (d) Live shorebirds trapped from intertidal wetlands in Vietnam’s Mekong Delta being sold for human consumption (2019) (Image sources: Ayuwat Jearwattanakanok, Phonesavanh Milavong, Bui Thanh Trung)
Not surprisingly we found widespread evidence of this species being trapped in paddy fields based on our fieldwork (Figure 1a), interviews, and from literature searches (including online hunting videos available on YouTube more than 30 videos found with details on trapping the species alone through unstructured searches) in major vernacular Asian languages (i.e., Vietnamese, Khmer, Thai). Meanwhile, smaller-bodied species (<25 g) are also being increasingly hunted as larger species become scarcer or become locally extirpated due to unsustainable take (Harrison et al., 2013; Sreekar, Huang et al., 2015).

Our surveys of food markets in towns and rural areas over 2019–2020 detected a high diversity of small-bodied passerine bird species for sale (Figure 1b and Table 1, also Table S1). Although none are globally threatened,

| District (market) | Total abundance (individuals) | Identified species | Forest species | Wetland/paddy associated species | Sampling effort |
|-------------------|-------------------------------|-------------------|----------------|---------------------------------|----------------|
| Cambodia          |                               |                   |                |                                 |                |
| Kampong Cham      |                               |                   |                |                                 |                |
| Bantheay          | 120                           | 8                 | 0              | 7                               | 1 day (October 2019) |
| Prey Veng         |                               |                   |                |                                 |                |
| Prey Veng         | c. 300                        | 12                | 0              | 10                              | 3 days (October 2019) |
| Lao PDR           |                               |                   |                |                                 |                |
| Bolikhhamxay      |                               |                   |                |                                 |                |
| Paksan            | 60                            | 5                 | 2              | 3                               | 2 days (November 2019) |
| Khamkert<sup>b</sup> (Lak Sao) | 135                  | 22                | 16             | 1                               | 3 days (November 2019) |
| Khammouane        |                               |                   |                |                                 |                |
| Hinboun           | 42                            | 12                | 9              | 1                               | 1 day (January 2020) |
| Xiangkhouang      | c. 10,500                     | 20                | 16             | 3                               | 3 Days (November 2019) |
| Salavan           |                               |                   |                |                                 |                |
| Salavan           | 42                            | 16                | 14             | 1                               | 1 day (March 2020) |
| Champasak         |                               |                   |                |                                 |                |
| Khong             | 16                            | 7                 | 2              | 0                               | 1 day (March 2020) |
| Myanmar           |                               |                   |                |                                 |                |
| Mandalay Region   |                               |                   |                |                                 |                |
| Mandalay<sup>a</sup> | 143                      | 6                 | 0              | 5<sup>d</sup>                   | 2 days (October 2019) |
| Sagaing Region    |                               |                   |                |                                 |                |
| Monywa            | 122                           | 5                 | 0              | 5<sup>d</sup>                   | 3 days (October 2019) |
| Rakhine State     |                               |                   |                |                                 |                |
| Sittwe            | 4                             | 4                 | 0              | 4                               | 1 day (December 2019) |
| Viet Nam          |                               |                   |                |                                 |                |
| Hanoi             |                               |                   |                |                                 |                |
| Mo Cho            | 188                           | 3                 | 0              | 1<sup>d</sup>                   | 1 day (October 2019) |
| Lang Hoa Lac      | 560                           | 13                | 0              | 13                              | 2 days (October 2019) |

<sup>a</sup>High counts of unidentified passerines, small bitterns, shorebirds (i.e. snipes), and quails (mostly de-feathered and difficult to identify).
<sup>b</sup>Markets known for wild meat being traded based on past surveys.
<sup>c</sup>Includes common snipe *Gallinago gallinago*, but potentially also other *Gallinago* species
<sup>d</sup>Counts contain high abundance of Barn Swallow *Hirundo rustica* (many de-feathered and difficult to identify) but also expected to contain other swallow species.
the observed numbers of swallows (Hirundinidae) sold for food exceeded 10,000 individuals based on just three days of surveys in Paek district, Xiangkhouang province, Lao PDR (Table 1). Indeed, large-scale, seasonal hunting of swallows for human consumption is known in Thailand (McClure, 1998; Round, 1990) and in Lao PDR, with take easily exceeding 100,000 individuals annually even in the 1990s (Evans et al., 2000). Like Xayyasith et al. (2020), we documented widespread hunting and trade of forest species such as bulbuls and flycatchers for domestic consumption, and to meet local and regional demand for wild meat (Table 1 and Figure 1). Our findings from market surveys appear consistent with published data from recent surveys of markets in rural areas in Myanmar, Lao PDR, and north-eastern India (Bhupathy et al., 2013; Brickle et al., 2008; Platt et al., 2012; Xayyasith et al., 2020), all of which have identified a diversity of forest species trapped and traded for food, such as barbets, pigeons and bulbuls, and migratory thrushes.

3 | NETS—SILENT KILLERS OF BIRDLIFE

Just as snares are well known to be an insidious threat to mammal populations across Southeast Asian forests (Gray et al., 2018), nets are an insidious threat to the region’s birdlife. The use of nets to trap birds for wild meat or the pet trade (Harris et al., 2017) is not new and has been variously documented (Aung et al., 2016; Zöckler et al., 2010) even though the exact scale of how it may affect wild birds is little assessed or estimated. In coastal Myanmar,

| Table 2 | Most frequently trapped species in mist nets based on snapshot field surveys in north (Lamphun, rice paddies) and Central Thailand (Suphan Buri; aquaculture ponds) in late 2019 and early 2020 |
| Species | Latin name | Landscapes sampled for mist nets |
| --- | --- | --- | --- | --- |
| | | Suphan Buri a | Abundance (%) total c | Lamphun b |
| | | | Abundance (%) total c | |
| Pond heron d,e | Ardeola sp. | 23 | 7.69 | 2 | 2.11 |
| Rock dove | Columba livia | 3 | 1.00 | 10 | 10.5 |
| Black-crowned night heron d | Nycticorax nycticorax | 9 | 3.01 | – | – |
| Great myna | Acridotheres grandis | 3 | 1.00 | 8 | 8.42 |
| Black drongo d | Dicrurus macrocerus | 7 | 2.34 | 6 | 6.31 |
| Cinnamon bittern d | Ixobrychus cinnamomeus | 1 | 0.33 | 6 | 6.31 |
| House sparrow | Passer domesticus | – | – | 5 | 5.30 |
| Little grebe | Tachybaptus ruficollis | 5 | 1.67 | – | – |
| Pheasant-tailed jacana d | Hydrophasianus chirurgus | 5 | 1.67 | – | – |
| Snipe d,e | Gallinago sp. | – | – | 6 | 6.31 |
| Western koel d | Eudynamys scolopaceus | 3 | 1.00 | – | – |
| White-breasted kingfisher | Halcyon smyrnensis | 2 | 0.66 | 3 | 3.16 |
| Indian cormorant | Phalacrocorax fuscicolis | 3 | 1.00 | – | – |
| Oriental pratincole d | Glareola maldivarum | 3 | 1.00 | – | – |
| Paddyfield pipit | Anthus rufulus | – | – | 3 | 3.16 |
| Red turtle dove | Streptopelia tranquebarica | 3 | 1.00 | – | – |
| Eastern spotted dove | Spilopelia chinensis | 3 | 1.00 | 10 | 10.5 |
| Wood sandpiper d | Tringa glareola | – | – | 3 | 3.16 |
| Yellow bittern | Ixobrychus sinensis | 3 | 1.00 | – | – |

Note: In Thailand, mist nets are widely used to exclude perceived pest birds in paddy fields and aquaculture, but some (trapped) birds are also harvested for consumption, especially herons and rails.

aTotal of >300 individuals sampled over March 2020 was identifiable to 29 species; mean trap rate = 7.7 individuals per net sampled (n = 40).
bTotal of 95 individuals sampled over November–December 2019 was identifiable to 31 species; mean trap rate = 9.5 individuals (n = 10).
cProportion of total is calculated based on data from each landscape. All mist-nets were only visited once during the surveys, so these figures do not reflect turnover.
dTaxa with known migratory populations in Southeast Asia.
eDifficult to identify genera with multiple species known in survey sites.
improvised fishing nets are known to be effectively deployed by local people to trap migratory shorebirds in large numbers, estimated to exceed 30,000 individuals per year (Zöckler et al., 2010). In our surveys, we found evidence of the widespread use of nets for hunting across countryside and production landscapes in the region (Figure 1c), such as paddy fields and aquaculture ponds in north and central Thailand (Table 2) and coastal areas in Cambodia (Figure 2) and Vietnam. Local people we interviewed in Cambodia, Lao PDR, and Vietnam acknowledged that nets, including commercially available mist-nets and improvised fishing nets, are now the most popular tools to trap birds and other wildlife (Figure 2). Several interviewees (Paksan and Khamkert, Bolikhamxay province, Lao PDR) described how they “used nets to trap swallows in the hundreds,” which in turn can be sold to middlemen and sellers in Xiangkhouang province as a food delicacy (Figure 3, and unpublished interview data, 2019–2020).

In Koh Kapik, Cambodia, interviewees described the use of fishing and mist nets to trap shorebirds (Figure 2), largely for a localized wild meat trade and domestic consumption during the “migratory season for waterbirds” (Figure 3, unpublished interview data). Nets were also found to be indiscriminately used to exclude species (e.g., bulbuls, starlings, weavers, munias) considered as pests in farming landscapes (e.g., paddy fields, orchards), mudflats used for clam culture (e.g., shorebirds in Vietnam) and aquaculture (for piscivorous birds such as herons, cormorants), with trapped individuals either opportunistically collected for consumption (unpublished interview data, Thailand, Vietnam) or left to die (unpublished interview data, Bangladesh, Thailand).

In one aquaculture landscape surveyed in central Thailand (Suphan Buri province) (area sampled = c. 1500 ha along a road-based, belt transect of 100 m width), we found >300 individuals representing at least 29 species trapped in 40 stretches of mist nets (Table 2). At another site, an area of paddy fields in northern Thailand (Lamphun province), we found that such nets held 95 individuals representing at least 31 species within 15 ha (Table 2). In southern Vietnam, we found 3–5 mist nets (averaging a length of 20 m per net) during shorebird surveys within a small area (∼10 ha, Can...
Gio and La Gi, Binh Thuan province) of aquaculture ponds and salt pans (Nguyen et al., 2020; Nguyen & Yong, 2021), and more in the wider landscape, consistent with observations in north Vietnam in the Red River Delta area (Ha & Phan, 2016). Affected taxa in these landscapes include wetland-associated species such as cormorants, terns, shorebirds, herons, and wildfowl (Table 2), as well as relatively large numbers of rails and shorebirds of multiple species (see Figure 1d, Wildlife Conservation Society 2009; Chowdhury, 2010; Nguyen et al., 2020; also Data S1).

Emerging work (e.g., Gallo-Cajiao et al., 2020; Nguyen et al., 2020) and our surveys are only beginning to unveil the scale of the use of nets for hunting birds across Indo-Burma, especially locally manufactured mist nets easily available to hunters and farmers (Figure 1c). The extent of both incidental catch and bycatch at places where nets are deployed remain unquantified at the local and regional scale, but is expected to be very high. Because much of the use of nets occurs in areas typically outside protected areas such as in agriculture fields and aquaculture ponds and often on privately owned land (e.g., Nguyen et al., 2020), there are major challenges in organizing surveillance to understand the full scale of the problem, and in implementing appropriate conservation measures.

4 OTHER FORMS OF BIRD HUNTING

Apart from nets, our fieldwork and questionnaires showed that several other hunting tools including bird decoys, sound playback using smartphones and other devices such as snares, hooks, catapults as well as poison baits are now prevalent across the Indo-Burma region. While shotguns are known to be widely used for hunting in parts of Indo-Burma (Thanh & Noi, 1999; Sreekar, Zhang, 2015; Chang et al., 2019), our interviews found shotguns to be less frequently used by local hunters compared to nets (Figure 2a,b), possibly because of increased law enforcement and confiscations in many Indo-Burma countries such as Cambodia, Lao PDR, and Vietnam. Until recently, it was very common for people living in the countryside near forested areas to own firearms for hunting, including homemade guns (Thanh & Noi, 1999). However, local people interviewed indicated that shotguns were still being used by hunters in forested landscapes (i.e., Lao PDR) to hunt canopy dwelling species such as barbets and pigeons (unpublished interview data, also Johnson et al., 2003) and wildfowl (e.g., ducks, geese) and herons in wetlands (e.g., Vietnam, Cambodia).

5 DISCUSSION

The scale of bird hunting in the Indo-Burma region is only beginning to become better understood (Banjade et al., 2020; Bhupathy et al., 2013; Dalvi et al., 2013; Nguyen et al., 2020; Xayyasith et al., 2020), alongside intensifying efforts to tackle the trade in pet birds and bird-derived ornaments (e.g., Jain et al., 2019; Lee et al., 2016; Marshall et al., 2020). Our concurrent field work in six Indo-Burma countries calls attention to the prevalence of hunting in poorly-surveyed landscapes outside protected areas in this biodiversity hotspot, such as paddy fields (Cambodia, Lao PDR, Myanmar, Thailand), orchards (Bangladesh), aquaculture (Bangladesh, Thailand, Vietnam) and coastal mudflats (Bangladesh, Myanmar, Vietnam)—these are landscapes overlooked in previous studies of wild meat trade and hunting by researchers focused on (forested) protected areas. The variety of hunting tools now used, such as decoys, mist nets, snares, glue sticks, catapults, and poison baits (Figure 2) have increasingly facilitated unsustainable harvest of wild birds, also flagged in existing studies (Evans et al., 2000; Platt et al., 2012), and even where bird populations have declined steeply (Chang et al., 2017). While the sustainability of these practices and its wider impacts on bird populations merit urgent study (also Evans et al., 2000), we warn that current levels of hunting and take, together with high mortalities when nets are used to exclude perceived pest birds, are already driving declines of bird species hitherto common in Indo-Burma, a trend already shown in other parts of Asia (SoIB, 2020; Heim et al., 2021).

Over time, we foresee that the increase in availability of hunting tools such as mist nets will increase the scale and extent of hunting while improved site accessibility through better roads is expected to “expand” hunting activities to remote, little-disturbed landscapes (Clements et al., 2014). There is therefore an urgent need for conservation practitioners to better understand, (1) the socioeconomic drivers of bird hunting (alongside broader investigations of the wild meat trade) and potential shifts towards hunting smaller-bodied species (as larger animals become extirpated), (2) the magnitude of different tool usage (e.g., mist nets, snares) on species take over time, especially species not red-listed or protected under national legislations, (3) the underlying trade chains and how these relate to rural communities and wild meat traders and, (4) impacts of the COVID-19 pandemic on hunting patterns by local people. Further study is especially needed in landscapes outside Indo-Burma’s protected areas, including multi-use agricultural landscapes such as paddy fields and fishponds frequented by migratory species (e.g., Harrison et al., 2016; Kasahara et al., 2020), and on farmland biodiversity.
Because most hunting activities typically occur at localized or landscape scales, and increasingly involve trapping and localized trade outside of protected areas, it is imperative that conservation practitioners support and work alongside local people, social scientists and the authorities in the development of by-laws and local initiatives to disincentivize illegal hunting or drive sustainable hunting practices. Such approaches may involve locally brokered agreements after extensive consultation to reduce or cease hunting activities in return for livelihood support, or the establishment of local-led conservation groups (Pilgrim et al., 2011; Pinto-Rodrigues, 2021). Against this backdrop, the implementation of conservation programs to create alternative livelihoods and encourage behavioral changes (of hunters) can be scaled-up in rural areas and among indigenous or minority communities, and in the vicinity of protected areas (e.g., Chang et al., 2019; Steinmetz et al., 2014). There is much scope to encourage community-led conservation initiatives already successfully pursued in some parts of the region (e.g., Aiyadurai & Banerjee, 2019; Steinmetz et al., 2014; Taufiqrurrahman et al., 2019), taking into consideration local livelihoods and complex socio-cultural factors (Johnson et al., 2003). Given limitations in capacity to enforce wildlife laws in the countryside outside protected areas, the active participation of local people, women, and ethnic minorities is critical (e.g., Chowdhury, 2010; Zöckler et al., 2010; Dalvi et al., 2013; Rao et al., 2011; Loke et al., 2020), especially in many parts of Indo-Burma where enforcement resources are limited, local hunting traditions are strong (e.g., in Lisu, Hmong, and Katu communities, among others, see Johnson et al., 2003; MacMillan & Nguyen, 2014; Zack, 2018) and relationships between local people and centralized authorities often strained.

There is also a need to better understand and address the gaps in conservation for birds afforded by weaknesses in existing legal frameworks (e.g., wildlife protection laws, protected area laws, decrees) under different contexts. For instance, three laws offer protection for wild birds in Vietnam, namely the Law on Forestry (effective in 2019), Law on Forest Protection and Development 2004, and the Law on Biodiversity 2008, alongside several decrees and directives. However, while Vietnam’s legal framework currently protects less than 30 species (Decree 64/2019/ND-CP dated 2019) albeit with heavy penalties (see Penal Code 2017), many species heavily impacted by trade and hunting remain unprotected by law (Nguyen et al., 2007) and/or are huntable outside protected areas. Similar legal gaps exist in other Indo-Burma countries. Added to this are the capacity limitations for on-ground implementation and enforcement. Yet, the impact of enforcement capacity to address hunting is evident in Vietnam’s Red River Delta in the much lower prevalence of bird hunting activities observed in Xuan Thuy National Park compared with the adjacent Tien Hai Nature Reserve, the latter with a smaller management team (Le, T.T. pers. obs.).

6 | CONCLUSION

Our fieldwork, while limited, offers a broad snapshot of Indo-Burma’s defaunation crisis from an avian perspective. We highlight that the unsustainable hunting of wild birds, or “avian defaunation,” across the region’s wetlands, agricultural landscapes, and rural countryside affects large numbers of (hitherto common, and non-red listed) species such as swallows, bulbuls, rails, and herons, many slipping through legal protections or enforcement “gaps.” Yet, there is surprisingly little monitoring of these species and the magnitude of them being hunted in non-forest landscapes, especially paddy fields, which has clearly escaped the attention of conservationists in Southeast Asia. This problem is accentuated by the little regulated use of hunting tools such as nets in the region. Without concerted conservation actions through a combination of strengthened legislation and enforcement, local livelihoods, and community-led mechanisms to address the exploitation of wildlife, Indo-Burma may eventually succumb to the specter of “empty wetlands and farmlands,” on top of the “empty forest” syndrome already being documented (e.g., Gray et al., 2018; Harrison, 2011; Harrison et al., 2016), while being confronted with the loss of previously common species and the irreversible loss of vital ecosystem services (Galetti & Dirzo, 2013) they provide.

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East and Southeast Asia, whilst working hard to raise the profile of migratory species conservation in this region.

CONFLICT OF INTEREST
The authors declare no conflicts of interest.

AUTHORS’ CONTRIBUTIONS
Ding Li Yong, Sayam Chowdhury, Anuj Jain, Vicky Jones, Emily Denstedt and Bou Vorsak were involved in overall research conceptualization and study design. All authors participated in data collection through field work in their respective countries, as well as the preparation, review and editing of the manuscript.

ETHICS STATEMENT
All aspects of this study involving structured interviews were approved by the respective implementing organizations, i.e., BirdLife International, the Wildlife Conservation Society and NatureLife Cambodia. Interviews are structured so that informants are unidentifiable from their responses.

DATA AVAILABILITY STATEMENT
Species data from market surveys in selected countries are available upon request. Data on observations of birds being trapped in nets in Thailand is currently being collected as part of an ongoing study led by R. Angkaew. Details: https://www.inaturalist.org/projects/netting-trapping.

ORCID
Ding Li Yong https://orcid.org/0000-0003-3115-6916
Anuj Jain https://orcid.org/0000-0001-9837-4163
Sayam U. Chowdhury https://orcid.org/0000-0002-1901-8900
Emily Denstedt https://orcid.org/0000-0003-4823-9726
Wich’yanan Limparungpathanakij https://orcid.org/0000-0002-5705-9455
Rongrong Angkaew https://orcid.org/0000-0002-1952-0415
Hoai Bao Nguyen https://orcid.org/0000-0002-7888-3099

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