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Characterizing the trade of wild birds for merit release in Phnom Penh, Cambodia and associated risks to health and ecology

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ABSTRACT

Demand for captive wild animals for the purposes of religious or 'merit' release has led to establishment of a large commercial trade in many parts of East and South Asia. The practice is associated with a number of risks to the integrity of wild populations including establishment of non-native species, introduction of pathogens and unsustainable rates of harvest. This study describes the sale of birds for merit release in Phnom Penh, Cambodia over a 13 month period. Birds were available throughout the year with an estimated annual turnover of 688,675 individuals. A total of 57 species were observed, all of which were considered native to Cambodia. Health surveys detected 43/415 (10.36%) birds carrying influenza A virus, 1/97 (1.03%) carrying *Chlamydophila psittaci*, and 4/97 (4.12%) carrying *Mycobacterium genavense*. Tests for *Mycobacterium avium* were unable to detect the bacterium. The zoonotic potential of each of these agents presents a risk both to public health as well as to wild populations. Without estimates of pre- and post-release mortality the impact of wild harvests for merit release cannot be assessed with certainty. However, 12,751 individual observations of the globally Near Threatened Asian golden weaver (*Ploceus hypoxanthus*), represents a significant portion of the estimated global population and is a cause for concern. Also of conservation concern are the low numbers of red avadavat (*Amandava amandava*) and yellow-breasted bunting (*Emberiza aureola*), both species that have undergone heavy declines due to historical over-exploitation, the latter now being classified as globally Vulnerable.

1. Introduction

The release of captive wild animals for spiritual or religious purposes is commonly practiced in many parts of eastern and southern Asia. Known as merit release, 'prayer release' or by the Chinese name *Feng Sheng*, the activity is rooted in Buddhist teachings, although the followers of other belief systems also participate to a lesser degree (Ahmed, 1997; Severinghaus and Chi, 1999; Chan, 2006; Liu et al., 2012). Within Buddhism, the liberation of animals from captivity is believed to be the most powerful means of attaining spiritual merit (Zangpo, 2005). Practitioners believe that relieving suffering and prolonging life will enhance personal karma, promoting advancement to a state of enlightenment. However, in many places, this act of benevolence has given rise to a commercial trade through which wildlife (primarily birds, fish and turtles) are captured solely for the purpose of merit release (McClure and Chaiyaphun, 1971; Sharma, 1999; Chan, 2006; Schoppe, 2008). Detailed accounts of the trade that supplies animals for this activity are limited, but surveys at the Bangkok Sunday Market from 1967 to 1968 estimated annual sales of 300,000 birds, representing 370 species, but did not distinguish between birds sold for merit release from sales for pets or as food (McClure and Chaiyaphun, 1971). Chan (2006) estimated annual sales of 680,000–1,050,000 birds for release in Hong Kong, and an estimated 128,000 birds for release each year were extrapolated from interviews at temples in Taichung City, Taiwan (Chen 1995, cited in Severinghaus and Chi, 1999) which together provides some context on the scale of the practice.

The ethics of supplying animals specifically for the purposes of release has been questioned on the grounds of animal welfare, ecological impact and health (Shiu and Stokes, 2008). The release of non-indigenous species can lead to the establishment of self-sustaining populations, with potentially deleterious effects on local ecology. The red-eared slider (*Trachemys scripta elegans*), a species that is commonly sold for release purposes (Goh and O'Riordan, 2007) has become the most abundant freshwater chelonian in many parts of Asia (Ramsay et al., 2007). The ecological impact of introduced sliders remains unresolved, but experimental studies have demonstrated a competitive advantage over native turtles

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(Cadi and Joly, 2003, 2004). Interbreeding between released exotics and native endemics has also resulted in cases of hybridization and genetic dilution, such as the case in Taiwan of released Chinese bulbuls (*Pycnonotus sinensis*) interbreeding with the endemic Styan's bulbuls (*Pycnonotus taivanus*) (BirdLife International, 2001).

The high density and unsanitary conditions that are often found in wildlife trade also have the potential to expose animals to novel pathogens or parasites, particularly when species that do not interact in the wild are housed together (Karesh et al., 2005; Edmunds et al., 2011; Gutiérrez et al., 2011). Release of infected individuals may then act as a vehicle for introducing pathogens into wild populations with consequences that are difficult to predict. Finally, the potential impact of excessive off-take on source populations should not be discounted, even for common species, as exemplified by the declines in the formerly abundant Java sparrow (*Padda oryzivora*), and yellow-breasted bunting (*Emberiza aureola*), that are now threatened due to trapping for commercial trade (BirdLife International, 2011).

The objective of this study is to provide a detailed account of the trade in wild birds for the purposes of merit release in Phnom Penh, Cambodia, with particular attention to assessing the risk to wild populations through non-native introductions, excessive off-take and health impact.

2. Methods

The study focused on two sites in Phnom Penh, Wat Phnom and the Riverside, where birds are regularly sold for merit release. Wat Phnom (N11.58, E104.92) is a Buddhist temple built on a small hill in the center of the city. At the time of the study, vendors sold birds both at the base of the hill, on the steps that lead up to the temple and around the temple itself. The Riverside (N11.56, E104.93) refers to a section of Sisawath Quay, directly opposite the Royal Palace, along the shores of the Tonle Sap River (Fig. 1). Vendors gather outside a small shrine (Preh Ang Dorng Kal), and sell birds to passers-by, either for release in the immediate vicinity, or occasionally other locations, such as weddings or private ceremonies. At the time of the study, these two sites were the main centers of merit bird sale in Phnom Penh, although smaller numbers of sellers also gathered at other temples elsewhere in the city (such as Sam Roung Andet, Sangkat Phnom Penh Thmey), with some vendors also using mopeds to take birds to special events on an opportunistic basis.

Fig. 1. Merit bird sellers along the roadside at Sisawath Quay, Phnom Penh, Cambodia.

Counts were made by four observers, who visited both sites on a near-daily basis from 28 March 2006 to 30 April 2007. Birds were held in cages containing anywhere from one to several hundred birds. The number and species of birds in each cage was recorded, with visual counts being cross-referenced with the number the trader thought present. In cases of disparity, the count was repeated until consensus was reached. All cages were counted once per day, with each observation being termed a "bird day" as birds observed on consecutive days could not be distinguished with certainty. Most counts (97%) were made before 9:00 h in order to maximize the numbers counted. The sellers quickly grew accustomed to the daily counts, and showed no hostility to the counters. The good rapport between counters and sellers made it possible to attribute each cage to an individual seller and their respective families. Data was analyzed using simple *t*-tests with Microsoft Excel software.

Four common pathogens of wild birds were selected as a means of assessing the health risk posed by the trade in merit birds: avian influenza virus, *Chlamydophila psittaci*, *Mycobacterium avium* and *M. genavense*. For avian influenza, oropharyngeal and cloacal swabs were collected from each bird and were preserved in a solution of guanidine isothiocyanate. Samples were collected from birds on 21 days from 30 October 2007 to 19 February 2009, after the completion of the bird counts. Sample collection was opportunistic and based on the compliance of sellers, and is not necessarily representative of the birds available for sale. For *Chlamydophila* and *Mycobacterium* testing, a sterile aluminum handled microswab was used to collect a cloacal sample, and absorb a blood spot from a toe clip. The swab was placed in a cryovial and dried and stored at −20C to reduce humidity. Oropharyngeal and cloacal swabs were tested by real-time reverse transcription polymerase chain reaction (rRT-PCR) targeting the matrix (MA) gene of the influenza A viruses (Runstadler et al., 2007). These tests were performed by the University of California Davis. For *Chlamydophila* and *Mycobacterium* testing, samples were submitted to Research Associates Laboratory, Dallas TX, to undergo real time PCR for target pathogens (Chevrier et al., 1999; Kauppinen et al., 2001; Geens et al., 2005). All tests that were used detect the presence of pathogen in the sample, rather than antibodies that would indicate prior exposure. Research was completed with the approval of the Ministry of Agriculture Forest and Fisheries, Royal Government of Cambodia.

3. Results

3.1. General overview

Birds were counted on 353 mornings from 28 March 2006 to 30 April 2007, representing 88.5% of days within the study period. Merit birds were available for sale on all days that the sites were visited. Vendors would purchase birds from a family that operated a wholesale business on the edge of the city, and bring the cages to the Riverside and Wat Phnom before dawn each day. Most traders purchased birds on credit, and would repay the wholesaler once birds had been sold. Occasionally members of the wholesaler family would bring birds to replenish the stocks of birds sold by the vendors during the course of the day.

Customers would begin purchasing birds in the early morning as they visited the temple and shrine, and sales would continue throughout the day. Any birds that died in the cages or soon after release were collected and later sold to street vendors that operated food stands that sold fried birds and insects in the evening. Any live birds remaining unsold at the end of the day were sold to food vendors, taken home for personal consumption, or held for sale the following day.

Table 1
A summary of birds counted at Wat Phnom and the Riverside, Phnom Penh during 353 visits between 28 March 2006 and 30 April 2007. Birds could not be distinguished on consecutive days, so counts represent a sum of birds observed each day (bird days).

Common name	Scientific name	Count	% of total
Scaly-breasted munia	*Lonchura punctulata*	270,041	35.0%
Barn swallow	*Hirundo rustica*	225,350	29.3%
Baya weaver	*Ploceus philippinus*	74,472	9.7%
Eurasian tree sparrow	*Passer montanus*	47,833	6.2%
Plain-backed sparrow	*Passer flaveolus*	40,165	5.2%
Streaked weaver	*Ploceus manyar*	26,684	3.5%
Sand martin	*Riperia ripera*	18,166	2.4%
Black-headed munia	*Lonchura Malacca*	13,057	1.7%
Asian golden weaver	*Ploceus hypoxanthus*	12,751	1.7%
Red avadavat	*Amandava amandava*	6767	<1%
House sparrow	*Passer domesticus*	4934	<1%
Yellow wagtail	*Motacilla flava*	3466	<1%
Oriental reed warbler	*Acrocephalus orientalis*	3362	<1%
Red-rumped swallow	*Cecropis daurica*	2411	<1%
Spotted dove	*Spilopelia chinensis*	1865	<1%
Common myna	*Acridotheres tristis*	1776	<1%
White-rumped munia	*Lonchura striata*	1679	<1%
Blue-tailed bee-eater	*Merops philippinus*	1387	<1%
Black-browed reed warbler	*Acrocephalus bistrigiceps*	1076	<1%
Yellow-breasted bunting	*Emberiza aureola*	542	<1%
Asian palm swift	*Cypsiurus balasiensis*	304	<1%
Rock pigeon	*Columba livia*	277	<1%
Forest wagtail	*Dendronanthus indicus*	259	<1%
White-vented myna	*Acridotheres grandis*	223	<1%
Black drongo	*Dicrurus macrocercus*	220	<1%
White wagtail	*Motacilla alba*	168	<1%
Brown shrike	*Lanius cristatus*	166	<1%
Lanceolated warbler	*Locustella lanceolata*	153	<1%
Yellow-vented bulbul	*Pycnonotus goiavier*	142	<1%
Plain prinia	*Prinia inornata*	139	<1%
Red collared dove	*Streptopelia tranquebarica*	139	<1%
Oriental magpie robin	*Copsychus saularis*	107	<1%
Green bee-eater	*Merops orientalis*	102	<1%
Striated grassbird	*Megalurus palustris*	90	<1%
Black-collared starling	*Sturnus nigricollis*	55	<1%
Yellow-bellied prinia	*Prinia flaviventris*	50	<1%
Chestnut-tailed starling	*Sturnia malabarica*	40	<1%
Streak-eared bulbul	*Pycnonotus blanfordi*	30	<1%
Red-breasted parakeet	*Psittacula alexandri*	27	<1%
Zitting cisticola	*Cisticola juncidis*	24	<1%
Common kingfisher	*Alcedo atthis*	21	<1%
Dusky warbler	*Phylloscopus fuscatus*	20	<1%
Purple-backed starling	*Sturnus sturninus*	14	<1%
Alexandrine parakeet	*Psittacula eupatria*	10	<1%
White-shouldered starling	*Sturnus sinensis*	10	<1%
Sooty-headed bulbul	*Pycnonotus aurigaster*	9	<1%
Indochinese bushlark	*Mirafra erythrocephala*	7	<1%
Richard's pipit	*Anthus richardi*	7	<1%
Common tailorbird	*Orthotomus sutorius*	6	<1%
Pied bushchat	*Saxicola caprata*	5	<1%
Common hoopoe	*Upupa epops*	4	<1%
Paddyfield pipit	*Anthus rufulus*	4	<1%
Plaintive cuckoo	*Cacomantis merulinus*	2	<1%
Barred buttonquail	*Turnix suscitator*	1	<1%
Bluethroat	*Luscinia svecica*	1	<1%
Common sandpiper	*Actitis hypoleucos*	1	<1%
Savanna nightjar	*Caprimulgus affinis*	1	<1%
Total		760,622	

Birds were sold by vendors operating either individually, or more commonly in distinct family groups. These families consisted of 'regular' sellers (observed at least once per calendar month in 11 or more of the 13 month study period), 'wholesalers', who acted as middlemen, buying birds directly from trappers and selling to regular sellers; and 'irregular' sellers who were present less frequently and sold directly to the public. The regular sellers comprised 12 families, representing 37 people (16 male and 17 female), with between one and seven people actively selling birds in each family. Many families would sell birds at both Wat Phnom and the Riverside simultaneously. One family dominated the wholesale market, with a second family supplying regular sellers during February and March 2007.

3.2. Bird numbers and diversity

In total 769,943 bird days were counted during the study period, with a mean daily count of 2181 bird days (SD 1720), a daily minimum of 104, and a daily maximum of 13,123 bird days. Replenishment of seller's stocks during the day was observed to occur, but is not included in these counts. Overall 760,622 birds were identified to species, with a total of 57 species observed. Counts were dominated by 10 species that represented 95.5% of all birds identified, with two species, scaly-breasted munia (*Lonchura punctulata*) and barn swallows (*Hirundo rustica*) alone constituting 64.3% of birds observed (Table 1).

A total of 10,023 cages were counted, with a mean of 76 birds per cage (SD 89.63). Up to nine species were observed per cage, with 47.5% of cages holding more than one species.

Daily turnover could not be determined accurately, but vendors reported expected sales in excess of 80% each day. On Upsala (Buddhist sabbath) days, consumer demand was greater and vendors expected to sell all of their birds. Survival of insectivorous species such as hirundines or warblers was lower than other species, and few if any of these survived long enough to appear in the cages on consecutive days. Assuming a daily turnover of 80% for non-hirundine species, on non-Upsala days, and 100% daily turnover for hirundines, and all birds on Upsala days the number of individual birds sold is estimated as 688,675 birds per year.

3.3. Cost of birds

The monetary value of birds both to vendors and wholesalers varied depending on the Buddhist calendar, and by species (Table 2). Based on these figures, and estimates of daily turnover, the annual sale of merit birds is worth an estimated US$444 931, and has a potential gross profit margin of US$235 693 to sellers as a whole (excluding overheads such as fees to market authorities and losses through bird mortality). For the 33 regular sellers, the mean potential annual profit is estimated at US$5 467 per person (before overheads). In Cambodia in 2006, the gross domestic product per capita, adjusted for purchasing power parity was US$1 705 (World Bank, 2011).

Table 2
A summary of the expected retail value of birds in Cambodian riel (KHR), and United States dollars (USDs), expressed both as a 'wholesale' price (paid by vendors to wholesalers), and 'street' price (paid by consumers to vendors).

	Non-Upsala days		Upsala days	
	Street price KHR (USD)	Wholesale price KHR (USD)	Street price KHR (USD)	Wholesale price KHR (USD)
Hirundine	1500 (0.38)	700 (0.18)	2500 (0.63)	1000 (0.25)
Non-hirundine	2500 (0.63)	1300 (0.33)	3500 (0.88)	1500 (0.88)

3.4. Temporal trends

Birds were sold throughout the year, with a peak in February (Fig. 2a). However, the composition of birds on sale varied seasonally, with some species such as scaly-breasted munia more evident in the dry season (December to May), and others such as Eurasian tree sparrow more evident during the wet season (May to December) (Fig. 2b and c). Abundance of barn swallows appeared to follow a modified dry season pattern, with a minor peak in September and October, presumably relating to capture of autumn migrants following the Mekong River (Fig. 2d).

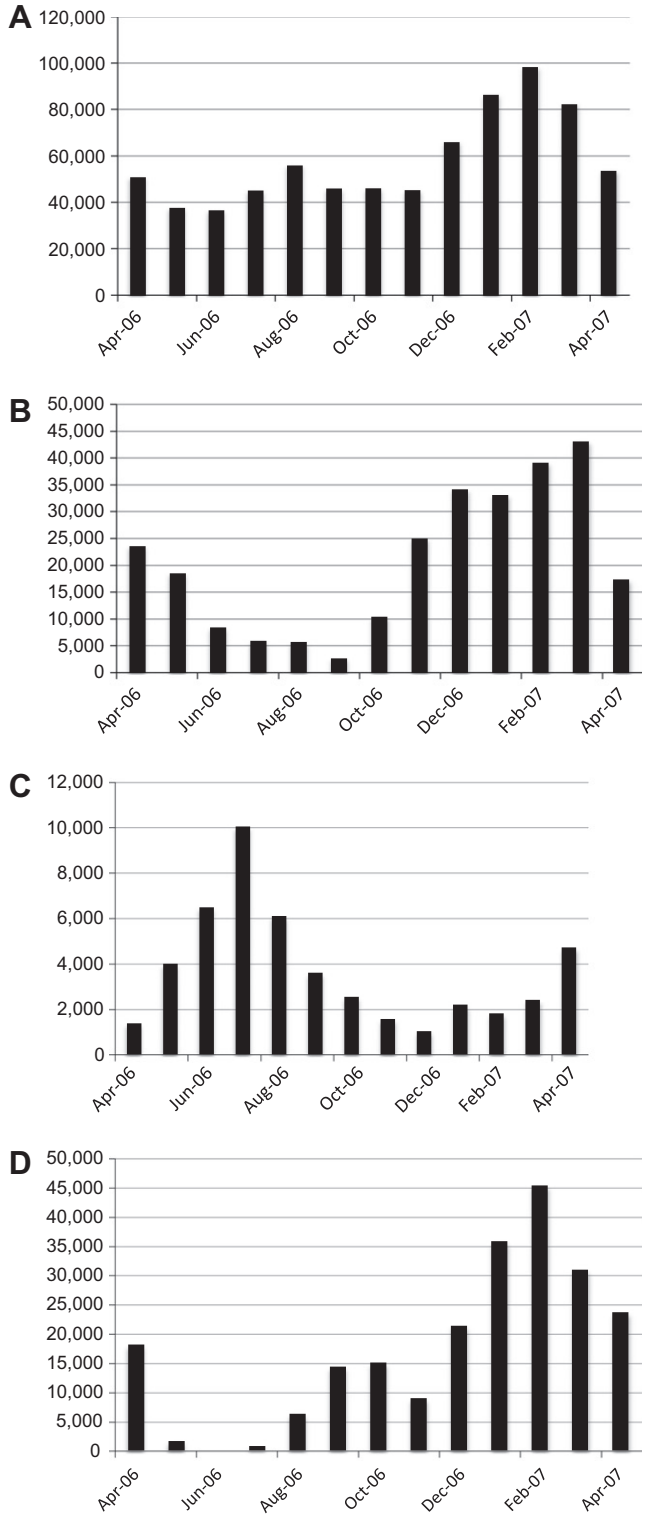

Fig. 2. Representation of cumulative monthly counts of birds observed for sale at Wat Phnom and the Riverside from 1 April 2006, to 30 April 2007, including counts of (a) all species combined, (b) scaly breasted munia (with a dry season peak), (c) Eurasian tree sparrow (with a wet season peak), and (d) barn swallow (with peaks in the dry season and autumn migration period).

The mean number of birds observed on Upsala days was 4818 (SD 2636), which was significantly higher than non-Upsala days (mean 1745, SD 990, $p < 0.001$). However, there was no significant difference found between the mean numbers of birds available on weekdays (mean 2184, SD 1670) compared with weekends (mean 2170, SD 1888, $p = 0.952$).

3.5. Health findings

Samples from a total of 414 individuals of 19 species were collected for avian influenza analysis, of which 43 birds (10.36%) from 11 species were found to be positive for conserved sequences on the matrix gene indicative of the presence of influenza A virus (Table 3). Overall, prevalence of avian influenza in the sample group was 0.10 (95% adjusted Wald confidence limits of 0.08–0.14).

Samples were collected from a total of 97 birds of four species for *Chlamydophila*, and *Mycobacterium* analysis (Table 4). Of these, one bird (an adult, female house sparrow, *Passer domesticus*) was found to be positive for *C. psittaci*, and four Eurasian tree sparrows (three adults and one juvenile) were found to be positive for *M. genavense*. No birds were found positive for *M. avium*. Across the birds sampled the prevalence of *C. psittaci* was therefore 0.01 (95% adjusted Wald confidence limits of 0.00–0.06), and 0.04 (95% adjusted Wald confidence limits of 0.01–0.10) for *M. genavense*.

4. Discussion

This study demonstrates the existence of a thriving trade in birds for merit release in Phnom Penh, Cambodia, with a large throughput in all months of the year. Due to the difficulty in distinguishing individual birds on consecutive days, it is not possible to state definitively how many individual birds pass through the merit bird trade system in Phnom Penh. However, the estimates of turnover expressed by the vendors themselves (in excess of 80% daily turnover for non-hirundine species on non-Upsala days, and 100% daily turnover on Upsala days and for hirundines throughout), seem realistic based on personal observation. The general condition of birds in the cages deteriorated rapidly during the course of a day, with damage to plumage or physical injury making them progressively less attractive to buyers over time. Insectivorous species, especially swallows or warblers fared particularly badly, and were unlikely to be present within the cages for more than a day. Taking account of the death and degradation of bird condition, and the credit system used by many to obtain their birds, it is unlikely that vendors would purchase considerably more birds than they felt able to sell within a day.

4.1. Origin and presence of non-native species

Almost without exception, the bird species observed were all native to Cambodia. According to the sellers, the birds were primarily trapped in surrounding provinces (Kandal, Takao, Prey Veng and Kampong Cham) and the outskirts of Phnom Penh itself. There was no indication that any birds were sourced internationally, as occurs in Taiwan and Hong Kong, and for this reason the threat posed by release of exotic bird species is not currently evident in Cambodia. Only one individual of one species, a black-headed

Table 3
A summary of RT-PCR findings in a cohort of birds sold for merit release in Cambodia, and tested for conserved matrix gene sequences indicating the presence of influenza A virus. Prevalence is presented with 95% adjusted Wald confidence limits (CL).

Order	Common name	Scientific name	Positive	Tested (N)	Prevalence (CL)
CORACIIFORMES	Common kingfisher	*Alcedo atthis*	–	1	0.00 (0.00–0.78)
CORACIIFORMES	Blue-tailed bee-eater	*Merops philippinus*	–	6	0.00 (0.00–0.36)
CUCULIFORMES	Plaintive cuckoo	*Cacomantis merulinus*	–	1	0.00 (0.00–0.78)
COLUMBIFORMES	Spotted dove	*Streptopelia chinensis*	1	29	0.03 (0.00–0.19)
COLUMBIFORMES	Peaceful dove	*Geopelia striata*	4	30	0.13 (0.05–0.30)
GRUIFORMES	White-browed crake	*Porzana cinerea*	–	1	0.00 (0.00–0.78)
PASSERIFORMES	Brown shrike	*Lanius cristatus*	–	1	0.00 (0.00–0.78)
PASSERIFORMES	Common stonechat	*Saxicola torquata*	–	1	0.00 (0.00–0.78)
PASSERIFORMES	Common myna	*Acridotheres tristis*	12	73	0.16 (0.10–0.27)
PASSERIFORMES	Barn swallow	*Hirundo rustica*	–	1	0.00 (0.00–0.78)
PASSERIFORMES	Oriental reed warbler	*Acrocephalus orientalis*	–	10	0.00 (0.00–0.25)
PASSERIFORMES	House sparrow	*Passer domesticus*	2	6	0.33 (0.09–0.70)
PASSERIFORMES	Plain-backed sparrow	*Passer flaveolus*	1	8	0.13 (0.00–0.49)
PASSERIFORMES	Eurasian tree sparrow	*Passer montanus*	9	79	0.11 (0.06–0.20)
PASSERIFORMES	Streaked weaver	*Ploceus manyar*	3	24	0.13 (0.04–0.32)
PASSERIFORMES	Baya weaver	*Ploceus philippinus*	2	48	0.04 (0.00–0.15)
PASSERIFORMES	Asian golden weaver	*Ploceus hypoxanthus*	1	7	0.14 (0.01–0.53)
PASSERIFORMES	Scaly-breasted munia	*Lonchura punctulata*	6	78	0.08 (0.03–0.16)
PASSERIFORMES	Black-headed munia	*Lonchura malacca*	2	10	0.20 (0.05–0.52)
		Total	43	414	0.10 (0.08–0.14)

Table 4
A summary of PCR findings in a cohort of birds sold for merit release in Cambodia, and tested for influenza A virus.

Common name	Scientific name	Total sampled (N)	*C. psittaci* positive	*M. genavense* positive	*M. avium* positive
House sparrow	*Passer domesticus*	3	1	–	–
Plain-backed sparrow	*Passer flaveolus*	6	–	–	–
Eurasian tree sparrow	*Passer montanus*	47	–	4	–
Scaly-breasted munia	*Lonchura punctulata*	41	–	–	–
	Total	97	1	4	0

bunting (*Emberiza melanocephala*) was considered extra-limital, but with records in northern Laos, Thailand, Vietnam and Malaysia it is likely that this represented a wild individual trapped in Cambodia.

4.2. Bird counts and off-take

The sheer numbers of birds observed on sale within the merit release cages in Phnom Penh does raise legitimate questions about the conservation impact of the activity. One species in particular, the Asian golden weaver (*Ploceus hypoxanthus*) was observed so frequently that a considerable portion of the global population could conceivably be passing through the merit release cages in Phnom Penh. Considering the estimated global population of only 10,000–19,999 birds (BirdLife International, 2011), a count of 12,751 bird days is alarming. Even accounting for the uncertainties in turnover rate within the cages (which vendors estimated at 80–100% per day depending on phase of the Buddhist calendar), and a possible underestimation of the global population, it is likely that off take at this scale could negatively impact the population in the wild.

Also recorded in this study and of potential conservation concern is red avadavat (*Amandava amandava*). Now described as an uncommon to rare resident in neighboring Thailand (Round, 2008), red avadavat has been exploited in Cambodia for many years. Delacour (Delacour, 1929) noted that individuals, mostly captured in Cambodia, are "exported by the thousands" through Saigon as cagebirds, however, by the early 1960s it was described as "uncommon and irregular" (Thomas and Poole, 2003). Populations in Cambodia are now thought to be low and of concern, and this is reflected by the numbers recorded in this study.

There is little historic data available to assess long-term trends in merit bird sales in Phnom Penh. Van Zalinge (van Zalinge, 1999) reported 18,440 birds of 27 species during counts made approximately three times a month at the Riverside over 12 months in 1995–1996. Direct comparison with this data is complicated, as neither time of day nor stage of the Khmer Buddhist calendar are noted. However, the observation that yellow-breasted bunting (*E. aureola*) was the most abundant migratory species observed (outnumbering barn swallows almost 2:1) contrasts with our study, where only 542 individuals were observed on 42 days. In the early 1960s this species was described as a common winter visitor in central Cambodia, with flocks of thousands feeding in ricefields, however, it was also simultaneously stated to be "killed in great numbers" (Thomas and Poole, 2003). As a result of such over-exploitation it has experienced dramatic declines, prompting a listing of Vulnerable on the IUCN red list (BirdLife International, 2010, 2011).

It could be argued that the impact of over-harvesting wild populations to meet demand for merit release does not equate to capture of wild birds for the pet trade or for food, as the birds involved are ultimately released and therefore represent a temporary loss to the wild population. However, this does not take account of mortality that occurs during the process of capture, confinement or after release. It was not possible to assess mortality within the merit cages in Phnom Penh, as the vendors quickly removed dead birds. However, studies elsewhere have reported variable levels of mortality of wild birds in trade that are highest prior to export (Anon, 2006). Furthermore, a study that attempted to use radio-telemetry

to determine survival of bulbuls and sparrows purchased from merit sellers in Hong Kong found that six of 12 birds died within 3 h to 10 d of release (Chan, 2006).

The establishment of self-sustaining populations of exotic species arising from merit release in Hong Kong and in Taiwan does indicate that a proportion of released birds do survive. In Hong Kong 19 species (15% of the breeding avifauna in the territory), are non-indigenous and have been introduced primarily from release of captive birds (Leven and Corlett, 2004). McClure (McClure, 1998) documents a Baya weaver (*Ploceus philippinus*) released in Bangkok that returned to a roost 120 km away and was "recaptured" for sale in Bangkok a further two times over the following 15 months. However, these rates of recapture vary markedly among species, with 40 weavers (*Ploceus* sp.) from 1900 banded at the Bangkok 'Sunday Market' observed for sale again after initial release, while only two of the 3800 marked yellow breasted buntings were resighted (McClure and Chaiyaphun, 1971). While these observations confirm that birds do survive the release process, it is not possible to infer from such anecdotal accounts how typical these are of the majority of birds that are released, and it is likely that post-release survival varies among species.

4.3. Health impacts

The presence of pathogenic viruses and bacteria among birds available for merit release is a concern both to wild bird populations and to humans involved in the trade. Each of the test pathogens is known to be zoonotic (with potential to pass between animals and people). Infection with influenza A viruses typically result in mild clinical signs, except for highly pathogenic strains belonging to some H5 and H7 subtypes which are capable of causing high mortality among birds and human patients (Capua and Alexander, 2007). Recent experimental studies using Eurasian tree sparrows sold for merit release have shown that they are capable of contracting highly pathogenic H5N1 virus, and carrying infections for up to 9 days before death (Gutiérrez et al., 2011). This study found infective virus in droppings, tissues and feathers, indicating the potential for human infections in people handling, or consuming infected birds. Human infections with highly pathogenic avian influenza virus H5N1 have a case fatality rate of approximately 60% (World Health Organization, 2011).

Transmission of *Chlamydophila* occurs among birds held in close proximity, with increased shedding linked to stressful conditions (Harkinezhad et al., 2009). Avian infections vary in severity depending on strain and host species. Human cases arise from inhalation of contaminated material, and vary in severity from inapparent infections to severe disease including interstitial pneumonia and encephalitis (Harkinezhad et al., 2009). *M. genavense* is a recently described zoonotic bacterium that causes severe infections in immunocompromised individuals such as human patients with AIDS (Bottger et al., 1992). In 2005 an estimated 130,000 people in Cambodia were living with HIV (low estimate 74,000 to high estimate of 210,000) (UNAIDS, 2006). Both of these bacterial pathogens have a faecal-oral transmission cycle, and so it is reasonable to assume that these agents would be amplified among populations of birds confined in high densities further elevating risks to health. The propensity of mixed species cages also encourages the exposure of birds to microorganisms and parasites to which they may not encounter in the wild.

There is some recognition within the Buddhist community that the commercialization of trade is dichotomous with the origins and spirit of the practice (Zangpo, 2005). These concerns have led to proposals to reduce the impact of merit release by encouraging practitioners to vary the timing, and location of merit purchases and species of animals used (Chan, 2006). However, at least in our study, these practices did not appear to be followed, with a predictable demand for birds throughout the year.

5. Conclusion

In contrast to Hong Kong and Taiwan, the trade in birds for merit release in Cambodia appears to be entirely domestic, thus avoiding the environmental risks associated with introduction of non-native species. Although very large numbers of birds are sold throughout the year in Phnom Penh, the impact of the wild harvest cannot be assessed without better understanding of source population size and pre- and post-release survival. However, observations of large numbers of the globally Near Threatened Asian golden weaver, representing a sizable portion of the estimated world population are a cause for concern. Also of concern are the low numbers of red avadavat and yellow-breasted bunting, both species that have undergone heavy declines due to historical over-exploitation, the latter now being classified as globally Vulnerable. Furthermore, the identification of three zoonotic pathogens within wild birds being sold for merit release represents a risk both to public health and to wild populations.

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References

Ahmed, A., 1997. Live Bird Trade in Northern India. TRAFFIC-India.
Anon, 2006. Animal health and welfare risks associated with the import of wild birds other than poultry into the European Union. Annex to the European Food Safety Authority Journal 410, 1–55.
BirdLife International, 2001. Threatened Birds of Asia: The BirdLife International Red Data Book. BirdLife International, Cambridge, UK.
BirdLife International, 2010. *Emberiza aureola*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>.
BirdLife International, 2011. IUCN Red List for Birds. <http://www.birdlife.org>.
Bottger, E.C., Teske, A., Kirschner, P., Bost, S., Chang, H.R., Beer, V., Hirschel, B., 1992. Disseminated "*Mycobacterium genavense*" infection in patients with AIDS. Lancet 340, 76–80.
Cadi, A., Joly, P., 2003. Competition for basking places between the endangered European pond turtle (Emys orbicularis galloitalica) and the introduced red-eared slider (Trachemys scripta elegans). Canadian Journal of Zoology/Revue Canadienne de Zoologie 81, 1392–1398.
Cadi, A., Joly, P., 2004. Impact of the introduction of the red-eared slider (Trachemys scripta elegans) on survival rates of the European pond turtle (Emys orbicularis). Biodiversity and Conservation 13, 2511–2518.
Capua, I., Alexander, D.J., 2007. Animal and human health implications of avian influenza infections. Bioscience Reports 27, 359–372.
Chan, S.W., 2006. Religious Release of Birds in Hong Kong. University of Hong Kong (Masters Thesis).
Chevrier, D., Oprisan, G., Maresca, A., Matsiota-Bernard, P., Guesdon, J.L., 1999. Isolation of a specific DNA fragment and development of a PCR-based method for the detection of *Mycobacterium genavense*. FEMS Immunology and Medical Microbiology 23, 243–252.
Delacour, J., 1929. On the birds collected during the fourth expedition to French Indo-China. Ibis 12, 403–429.
Edmunds, K., Roberton, S.I., Few, R., Mahood, S., Bui, P.L., Hunter, P.R., Bell, D.J., 2011. Investigating Vietnam's ornamental bird trade: implications for transmission of zoonoses. EcoHealth 8, 63–75.
Geens, T., Dewitte, A., Boon, N., Vanrompay, D., 2005. Development of a *Chlamydophila psittaci* species-specific and genotype-specific real-time PCR. Veterinary Research 36, 787–797.

Goh, T.Y., O'Riordan, R.M., 2007. Are tortoises and freshwater turtles still traded illegally as pets in Singapore? Oryx 41, 97–100.
Gutiérrez, R.A., Sorn, S., Nicholls, J.M., Buchy, P., 2011. Eurasian tree sparrows, risk for H5N1 virus spread and human contamination through buddhist ritual: an experimental approach. PloS One 6, e28609.
Harkinezhad, T., Geens, T., Vanrompay, D., 2009. *Chlamydophila psittaci* infections in birds: a review with emphasis on zoonotic consequences. Veterinary Microbiology 135, 68–77.
Karesh, W.B., Cook, R.A., Bennett, E.L., Newcomb, J., 2005. Wildlife trade and global disease emergence. Emerging Infectious Diseases 11, 1000–1002.
Kauppinen, J., Hintikka, E., Iivanainen, E., Katila, M., 2001. PCR-based typing of *Mycobacterium avium* isolates in an epidemic among farmed lesser white-fronted geese (Anser erythropus). Veterinary Microbiology 81, 41–50.
Leven, M.R., Corlett, R.T., 2004. Invasive birds in Hong Kong, China. Ornithololological Science 3, 43–55.
Liu, X., Mcgarrity, M.E., Li, Y., 2012. The influence of traditional Buddhist wildlife release on biological invasions. Conservation Letters 5, 107–114.
McClure, H.E., 1998. Migration and Survival of the Birds of Asia. White Lotus, Bangkok, Thailand.
McClure, H.E., Chaiyaphun, S., 1971. The sale of birds at the Bangkok "Sunday Market" Thailand. Natural History Bulletin of the Siam Society 24, 41–78.
Ramsay, N.F., Kaye, P., Ng, A., O'Riordan, R.M., Chou, L.M., 2007. The red-eared slider (Trachemys scripta elegans) in Asia: a review. In: Gherardi, F. (Ed.), Biological Invaders in Inland Waters: Profiles, Distribution, and Threats Volume 2, Invading Nature. Springer, Dordrecht, The Netherlands.
Round, P., 2008. The Birds of the Bangkok Area. White Lotus Co., Ltd., Bangkok, Thailand.
Runstadler, J.A., Happ, G.M., Slemons, R.D., Sheng, Z.-M., Gundlach, N., Petrula, M., Senne, D., Nolting, J., Evers, D.L., Modrell, A., Huson, H., Hills, S., Rothe, T., Marr, T., Taubenberger, J.K., 2007, RRT-PCR analysis and virus isolation to determine the prevalence of avian influenza virus infections in ducks at Minto Flats State Game Refuge, Alaska, during August 2005. Using Archives of Virology 152, 1901–1910.
Schoppe, S., 2008. Science in CITES: The Biology and Ecology of the Southeast Asian Box Turtle and its Uses and Trade in Malaysia. Petaling Jaya, Selangor, Malaysia.
Severinghaus, L.L., Chi, L., 1999. Prayer animal release in Taiwan. Biological Conservation 89, 301–304.
Sharma, D.S.K., 1999. Tortoise and Freshwater Turtle Trade and Utilisation in Peninsular Malaysia. Petaling Jaya, Selangor, Malaysia.
Shiu, H., Stokes, L., 2008. Buddhist animal release practices: historic, environmental, public health and economic concerns. Contemporary Buddhism 9, 181–196.
Thomas, W.W., Poole, C.M., 2003. An annotated checklist of the birds of Cambodia from 1859–1970. Forktail 19, 103–128.
UNAIDS, 2006. Report on the Global AIDS Epidemic. A UNAIDS 10th anniversary special edition. Geneva, Joint United Nations Programme on HIV/AIDS, 2006.
World Bank, 2011. GDP per capita, PPP. <http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD>.
World Health Organization, 2011. Archive of Tables with Cumulative Number of Confirmed Human Cases of Avian Influenza A (H5N1) Reported to WHO. <http://www.who.int/influenza/human_animal_interface/H5N1_cumulative_table_archives/en/index.html>.
van Zalinge, N., 1999. Bird sales in Riverside market, Phnom Penh. Cambodia Bird News 2, 30–33.
Zangpo, S., 2005. Releasing Life: An Ancient Buddhist Practice in the Modern World. The Corporate Body of the Buddha Educational Foundation, Taiwan.