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Short Communication

Wildlife trade shifts from brick-and-mortar markets to virtual marketplaces: A case study of birds of prey trade in Thailand

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ABSTRACT

The shift of wildlife trade from brick-and-mortar markets to virtual online marketplaces is reported using the trade of birds of prey (raptors) in Thailand from 1968 to 2019 as a case study. We analyzed data obtained from physical market survey data for 2,782 individuals from 27 species, with 2,420 individuals reported in early surveys (1968-1988) and 362 individuals reported in later surveys (2003-2015) and online surveys (February 2017 to January 2019). We compared information on asking prices and what species were traded using two comparative approaches to analyze how species composition may have changed over time (physical markets and online platforms; pre-Internet and Internet era). In comparison with the five previous market surveys, we did not find a statistically significant difference between species and availability of species offered for sale when comparing physical bird markets and online markets. In all data sets, biological factors such as wingspan were significant factors in explaining price variation. We conclude that sustained monitoring is needed to make direct comparisons between the trade platforms. With a continued increase of wildlife trade on online platforms, we recommend increased regulation and enforcement of wildlife trade laws.

Introduction

Global trade in wildlife is a multibillion dollar industry (Rosen and Smith 2010; Wyler and Sheikh 2013). Wildlife is traded for a multitude of purposes, including for pet purposes, food, medicine, luxury products, and collectable items (Baker et al 2013). Unregulated commercial trade and unsustainable harvesting from wild populations lead to increased extinction risks for many taxa around the world (Tingley et al 2017). Traditionally, the platforms of trade have strictly been limited to physical trading areas ranging from city markets, border markets, trading hubs at ports, and stores (Zhang et al 2008). Using data of live animals sold in local markets throughout East and Southeast Asia, Karesh et al (2005) conservatively estimated that tens of millions of wild animals are shipped across the region each year for food and medicine.

As observed with the trade of many wildlife species, there has been a clear shift in wildlife trade platforms from traditional brick-and-mortar markets toward online platforms (Lavorgna 2015). As part of increased globalization, trade of wildlife on online platforms has become increasingly popular and for several taxa now has overtaken the trade in physical markets (Rodríguez et al 2007; Sung and Fong 2018; French 2019).

Modernization of transport and increased interconnectivity has eased the way online purchases can be made, and as a result, enabled the trade of millions of wild animals to be more accessible and quicker (Karesh et al 2005). Theoretically, the complex interactions within markets, both physical and online markets, as well as legal and illegal, have been explored to a limited extent (Fischer 2004). To date, there have only been a number of studies that examined this market place transition quantitatively. The challenges in making direct comparisons between physical markets and online platforms range from disjointed time periods, nuanced social differences in consumer buying behavior, as well as differences in survey methods and efforts. Nijman et al (2019) directly compared open animal markets and online markets in trade of wild cats and revealed that there is indeed a directional shift of trade toward online platforms but this differs generally between countries. An increased presence of enforcement agencies in many traditional markets may have also contributed to the shift; however, the rate of change occurs at varying degrees dependent on factors such as geographic location and infrastructure limitations.

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Of all the wildlife that is traded globally, the trade in wild birds is one that is well documented. Birds are arguably one of the most popularly traded taxa, contributing as the most species rich and abundant class of wildlife traded legally based on records from 2006 to 2012 (Bush et al 2013). Traditionally, birds are kept as pets in many societies around the world but probably no where more so than in Southeast Asia (Lin 2005; Nijman et al 2018). However, not all of this trade is regulated and sustainable; over a third of bird species are impacted by overexploitation (Harris et al 2017; Reuter et al 2019). Trade has also been cited as the second most significant threat to migratory birds (Brochet et al 2016).

The trade of live diurnal birds of prey (Falconiformes and Accipitriformes), commonly referred to as raptors, contributes to a significant proportion of the avian trade (Panter et al 2019). Raptors are legally and illegally traded for recreational hunting or falconry, especially in the Middle East and USA, or for them to be kept as pets (Nijman et al 2009; Wyatt 2009; Roldan-Clara et al 2014; MaMing et al 2014). Although not common, in some cultures, raptors are also hunted and consumed as medicine or bushmeat (Zhang et al 2008; Buji et al 2015). With the challenges involved in captive breeding of many species, raptors observed in trade are often caught from the wild (MaMing et al 2014; Nijman et al 2009). A recent analysis of the global raptor trade from 1975 to 2015 revealed that though current legal commercial trade seems to not pose large conservation concern, there remains a lack of quantifiable evidence on the extent and impact of unregulated trade (Panter et al 2019; Wyatt 2011). Legal and illegal trade in live raptor species have been reported globally, for example, in Indonesia (Nijman et al 2009, Eaton et al 2016), Japan (Vall-llosera and Su 2018), and Russia (Wyatt 2009, 2011). The noted increased raptor trade on social media platforms has also been flagged up (Iqbal 2015; 2016; Gunawan et al 2017; Nijman 2020). Unregulated trade not only threatenes species populations in the wild, but also poses a threat in terms of zoonotic disease transmission. have been multiple reported cases where raptor species have been recorded in transmitting highly pathogentic avian influenza A/H5N1 virus (Van Borm et al 2005; Steensels et al 2007; Shivakoti et al 2010).

Thailand is one of the countries that have an in-depth record of trade in wildlife markets dating back to the 1960s. Online wildlife trade has also been expanding; in a quick assessment over a 23-day period in 2018 revealed over 200 species (95 of which were birds) offered for sale on Facebook (Phassaraudomsak and Krishnasamy 2018), while an another 18-month study found nearly 1200 individuals from 42 species offered for sale; the majority of these species were not allowed to be traded commercially (Siriwat et al 2019). One of the reasons for this increased popularity is that social media plays an integral role in Thailand's modern society, with over 50 million Facebook users, earning a rank of eighth globally among Facebook users (Leesa-nguansuk 2018). Enforcement agencies and Facebook has indeed cracked down on wildlife trade on social media platforms; however, in a cat–mouse manner, traders consistently reopen groups or use maneuvers to evade from regulators and authorities, as a result, trade still exists.

We explore the shift of wildlife trade from physical markets to online platforms using two separate data sources. For market data, we conducted a literature review of previous surveys using two comparative approaches to analyze how species on offer may have changed over time. For recent online data, we report our findings on online trade in raptors over a two-year data monitoring period, collecting information on species on offer and asking prices. First, we made a comparison based on trade platform, that is, market (data from physical brick-and-mortar markets) and online (e-commerce and social media platforms) surveys. Second, we made a temporal comparison, using the "Internet era" as a defining marker: pre-Internet (before 1995) and post-Internet (after 1995). We defined the start of the Internetera as the year 1995 as in that year for the first time computers outsold TV sets (Newell 2001). We created models to explain the variability in the number and composition of the species in trade, using predictor variables such as body size (wingspan), clutch size, migratory status, and conservation status. Using data on asking prices from our two-year study, we explored the aforementioned variables to explain variation in price and to analyze temporal trends and seasonality. Based on our findings, we recommend increased monitoring and improved legal protection and enforcement for species.

Material and methods

Market survey (*including literature review*)

We collated market survey data on the bird trade in Thailand from previous bird market surveys conducted in Thailand. The surveys have been predominantly conducted in one location, Chatuchak Weekend Market in the capital Bangkok. We compiled data from McClure and Chaiyaphum (1971), Round (1990), Nash (1993), Round and Jukmongkkol (2003), and Chng and Eaton (2015). We recorded survey dates, the number of visits, total birds observed, species, and the number of birds of prey observed. Where available, we also collected data on temporal, availability (numbers sold per month), and price.

We surveyed Chatuchak Weekend Market for the presence of birds of prey between June 2011 (two visits) and December 2018 and February 2019 (three visits). The bird market in Chatuchak has moved from past surveys and now predominantly is focused on zone D, behind J.J. Mall. Surveys were conducted by walking through markets and recording species and numbers in notebooks or on mobile phones (cf. Nijman et al 2019).

Online survey

A search for exotic pet groups was conducted on Facebook using search terms in Thai and English. We joined every group that could be searched and found by anyone with a Facebook account. In some cases, the group status may be closed and therefore we required approval to enter. We joined eight groups and conducted monitoring sessions online from February 2017 to January 2019. We follow our previous methods in collecting data on Facebook (cf. Siriwat et al 2019). Of the eight groups, one group primarily focused on birds, and the remaining seven groups sold a variation of exotic pets.

From February 2017 to January 2019, we collected data on birds of prey for sale and recorded species, the number of individuals, price, date, and any information that may inform on trade methods (cf. Siriwat and Nijman 2018). We monitored each group on a monthly basis and used approaches by Iqbal (2016) who used the Facebook group photo limit to determine each monitoring session. Facebook archives a limited each group archives to 5,000 photos at any given point, and once the entire archived is loaded, it is considered the end of a monitoring session. We cross-referenced duplicated posts using usernames and photos and removed duplications from further analysis. We then subsequently anonymized the usernames.

Species were identified based on the description from the caption given by the sales poster. Only one post could not be identified to species level due to a lack of description and the bird chicks in the photo was too young; this was removed from further analysis. We followed the taxonomy of Eaton et al (2016). Price data were collected in Thai baht and presented here in US$ based on a conversion rate of THB 33.01 = US$ 1 (exchange rate ranged from 31.21 to 35.13 Thai baht within the monitoring period).

Ethical and legal considerations of online surveys

Traditionally, researchers interested in the live trade of animals would visit open markets, wholesalers or pet shops; observe the trade, identify and count the number of individuals for sale; and record prices and husbandry practises, as indeed performed by McClure and Chaiyaphum (1971), Round (1990), Nash (1993), Round and Jukmongkkol (2003), and Chng and Eaton (2015) in Chatuchak market. They may or may not have interviewed the traders and the customers to obtain more detailed information. In many cases, the trade in live raptors occurs in the open, as animals can only be sold if a potential customer has the opportunity to see what is on offer. There where the trade does happen in the open in public, all those involved can have a reasonable expectation that they can be observed by others, just like when visiting any other public space. A small percentage of the trade does occur out of sight, in back alleys or at traders' premises, and can only be observed when one is accepted as part of the group; researching this type of trade is much more complex and, to the best of our knowledge, with respect to the trade in raptors, has been rarely reported.

In practise, a large part of the online trade in raptors is not all that different from the trade in an open, public space. It is in the best interest of the sellers to ensure that as potential customers have the opportunity to see and buy whatever they have on offer. While a small proportion of wildlife trade occurs out of sight, in the "back alleys of the Internet", or even on the dark web, the proportion is small (Harrison et al 2016). In the case of the global trade in raptors as pets or to be used in falconry, it is largely irrelevant. The online trade in raptors as pets occurs in the open. For instance, many of the Facebook groups where birds of prey are offered for sale are classified as "open" or "public" and have their privacy settings set at a level where it is very easy to observe or join a group. Once joined, posts and comments can be seen by all those that are part of that group, as well as everyone else who wishes to do so. The number of members that have joined groups is often in the 10,000s – in our study group member volume ranged from 7,763 to 31,557, with a mean of 18,042 members per group at the last period of monitoring. As such, one can have a reasonable expectation to be observed, perhaps even more so than when entering a public space such as a town square or an animal market. Indeed Burkell et al (2014) concluded "…the online social spaces are indeed loci of public display rather than private revelation: online profiles are structured with the view that "everyone" can see them, even if the explicitly intended audience is more limited. These social norms are inconsistent with the claim that social media are private spaces; instead, it appears that participants view and treat online social networks as public venues."

We followed a typical economic market approach and used market survey protocols in each monitoring session to observe what was being traded (Nekaris et al 2010, Barber-Meyer 2010). There are several approaches possible in conducting Facebook market surveys. For instance, Hinsley et al (2016) conducted a questionnaire survey to gain insight into the online orchid trade. The approach taken by Hinsley et al (2016) was to publicly state the status of "researcher" and declare the intentions to collect data on orchid trade. Thereby, the researchers used the acknowledgment as a form of consent to access closed groups (Hinsley et al 2016). While other studies do not specify methods carried out for data collection but choose not to disclose specifics of forum name such as site name and address (Sung and Fong 2018). Machine learning techniques are also becoming incorporated to investigate illegal wildlife trade on social media using the three-step idea of mining, filtering, and identifying data. However, this approach is still in its early stages, and frameworks still need to be explored particularly related to data security and privacy requirements where researchers are based (Di Minin et al 2018).

We used a manual observation in our market survey to record, filter, classify, and assess legal and illegal trade (Eid and Handal 2018). Owing to the potentially sensitive and illegal activity on the groups, we abided by ethical guidelines from Roulet et al (2017) to conduct covert observations. We did not interact with any participants or access any personal profile pages and only collected information that was publicly displayed. Data were also anonymized after cross-checking for duplicates, and no information after the monitoring session can be attributed to one person (cf. Kosinski et al 2015; Martin et al 2018);only photographs that were uploaded on to the Facebook groups we collected on the day of data collection and stored on an encrypted drive (cf. Eid and Handal 2018).

Statistical analyses

In the analysis, using the online survey results, we explore the relationship between price and availability by testing for an anthropogenic Allee effect (Courchamp et al 2006, Holden and McDonald-Madden 2017) at the individual level and species level using linear regressions. For seasonality, we accumulated availability per month and used a χ^2 test to assess the correlation of availability per month.

We also created a generalized linear model (GLM) in using the Statistics Software Package for the Social Sciences (SPSS; IBM Corp 2018) to model for factors which may explain price data using the variables which describe species characteristics such as wingspan and clutch size (Table 1). The species population trends and migratory status, as listed in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species were also included. Additional availability (number of individuals) was included as an additional weighted variable. Continuous variables were log-transformed if not normalized. We used GLMs and chose the most parsimonious model with the lowest positive Akaike Information Criterion score. We reported Wald χ^2 values from the GLMs and associated p-values. In the meta-analysis, we conducted analyses at a species level. We incorporated factors that may explain availability using the same variables in Table 1.

Results

The raptor trade in Thailand is summarized using data from four surveys which were conducted in physical bird markets and two surveys on online trade platforms (Table 2). Physical market surveys reported trade in 2,782 individuals from 27 species, with 2,420 individuals reported in early surveys (1968-1988) and 362

Table 1. Variables included in the generalized linear model to explain availability (number of individuals) or price.

Variable	Definition/reason
Availability	The number of individual birds traded
Price	The average price offered in US $
Wingspan	Indicator of body size; the length of the wingspan of raptor species traded ranged from 10.1 to 56.3 cm. Wingspan was ordinally categorized in groups of 5.0 cm.
Clutch size	Indicator of life cycle; the number of clutch sizes of raptor species traded ranged from 1 to 5 eggs.
IUCN trend	IUCN Red List population trends were used as an indicator of rarity. Populations were evaluated as stable, decreasing or unknown. All but one raptor species traded are listed as least concern.
Migratory status	Movement patterns according to the IUCN; migratory statuses of raptor species were included in the model to explore if this has an impact on availability or price

Table 2. Raptors for sale in Thailand in Chatuchak market in Bangkok and online on Facebook for the period 1968 to 2019. Only individuals that were identified to the species were included.

Species	Bird market				Online	
	Pre-Internet		Internet			
	A (1968–1969)	B (1987–1988)	C (2003)	D (2015)	E (2016)	F (2017–2019)
Shikra *Accipiter badius*	37	1			22	28
Crested goshawk *Accipiter trivirgatus*	58				8	34
Besra *Accipiter virgatus*	93					1
Black baza *Aviceda leuphotes*	19				3	3
Rufous-winged buzzard *Butastur liventer*	63	6			3	2
Hen harrier *Circus cyaneus*	21					
Pied harrier *Circus melanoleucos*	6					
Eastern marsh harrier *Circus spilonotus*		1				
Black-shouldered kite *Elanus caeruleus*	322	61	5	9	22	49
White-bellied sea eagle *Haliaeetus*	1				1	1
Gray-headed fish eagle *Haliaeetus ichthyaetus*	12					
Brahminy kite *Haliastur indus*	12	3			11	51
Rufous-bellied eagle *Lophotriorchis kienerii*	1					1
Black eagle *Ictinaetus malaiensis*	1					1
Black kite *Milvus migrans*	402	6		2	2	3
Crested serpent eagle *Spilornis cheela*	50	44			5	20
Blyth's hawk-eagle *Nisaetus alboniger*	3				2	24
Changeable hawk-eagle *Nisaetus cirrhatus*	27				1	24
Wallace's hawk-eagle *Nisaetus nanus*						1
Mountain hawk-eagle *Nisaetus nipalensis*						2
Oriental honey buzzard *Pernis ptilorhynchus*						2
Oriental hobby *Falco severus*	1					
Common kestrel *Falco tinnunculus*	1					10
Brown falcon *Falco berigora*[a]					8	
Peregrine falcon *Falco perigrinus*					2	
Collared falconet *Microhierax caerulescens*	971	2				
White rumped falconet *Polihierax insignis*	164	31				
Total species	21	9	1	2	13	17
Total individuals	2265	155	5	11	90	256

A = McClure and Chaiyaphun, 1971; B = Round 1990; C = Round and Jukamongkkol 2003; D = Chng and Eaton 2015; E = Phassaraudomsak and Krishnashami 2018; F = this study.

[a] native to Australia and New Guinea; possibly misidentified.

individuals reported in later surveys (2003-2019). Over the study periods, market surveys were conducted in Chatuchak for all surveys. Two surveys were conducted in 2019 and 2020 and no trade of raptors was reported.

Overall online survey findings

From February 2017 to January 2019, we found 17 species of birds traded, totaling 261 individuals offered for sale on Facebook (Table 3). All birds are listed as "Least Concern" under the IUCN Red List of Threatened Species, with the exception of Wallace's hawk eagle (*Nisaetus nanus*) which is currently listed as "Vulnerable". All birds of prey found traded are found in Thailand and protected under Thailand's wildlife laws. Based on 84 posts where geographic information was available, posts originated from 23 provinces in Thailand and 4 posts were from Indonesia. Within Thailand, most posts originated from the southern region of Thailand with most from Yala Province (n = 13), followed by Bangkok (n = 12); (Figure 1A). Two posts based in Thailand advertised that the listed birds (both crested serpent eagle, *Spilornis cheela*) were from Malaysia. At the individual level analysis, we found a statistically significant correlation between the number of individuals offered per post and the offer price ($R^2 = 0.040$; $F(1, 135) = 5.698$, $P = 0.018$; Figure 1B), that is, when more birds were offered per post, the average prices on offer decreased.

Distribution of species over time

We compared species distribution of raptors traded in the time period of pre-Internet (surveys A and B) and post-Internet era (surveys C and D) (Table 2). We found that there was not a statistically significant difference [$t = 1.92$, degree of freedom (df) = 26, $P = 0.065$]. A comparison was also made for the physical market (A-D) and online surveys (E-F) which also was not a statistically significant difference ($t = 1.94$, $df = 26$, $P = 0.063$). Therefore, it can be said that the number of individuals per species found are not statistically different over for both comparisons, over the entire time period.

We ran a GLM using price data on our data based on the 24-month data, to explain price using factors of body size (wingspan), clutch size, IUCN trend, migratory status as model variables, and the number of individuals as a weighted factor. We found that in our best fit model, all variables were significant factors to explain price (Table 4a). Clutch size correlated inversely with both availability and price. Based on the model, species that have decreasing trends on the IUCN Red List and are migratory were offered at higher estimated means prices.

We also modeled using availability (physical markets and online platforms) as a dependent factor and factors of body size (wingspan), clutch size, IUCN trend (stable or decreasing), and migratory status as variables. In the best fit model, the availability in physical markets could be significantly explained by wingspan, where higher numbers of smaller birds were found traded (Table 4b–c). In the best fit model for online surveys, we find that wingspan, clutch size (more frequently for smaller nests), and IUCN trend (more commonly found if trend more decreasing) all significantly explained availability.

Seasonality

In the online survey, we did not find an equal distribution of species across the months ($\chi^2 = 100.32$, $df = 11$, $P < 0.0001$), where

Table 3. Birds found traded from 8 Facebook groups in the period of February 2017 to January 2019.

Common name	*n* (posts)	*n* (indiv)	Mean price (US $)	Trend[a]	Movement pattern (migration)[a]
Shikra *Accipiter badius* (เหยี่ยวนกเขาชิครา)	19	28	55	Stable	Migratory
Crested goshawk *Accipiter trivirgatus* (เหยี่ยวนกเขาหงอน)	27	34	122	Decreasing	Non-migratory
Besra sparrowhawk *Accipiter virgatus* (เหยี่ยวนกกระจอกเล็ก)	1	1	30	Decreasing	Migratory
Black baza *Aviceda leuphotes* (เหยี่ยวกิ้งก่าสีดำ)	2	3	59	Decreasing	Migratory
Rufous-winged buzzard *Butastur liventer* (เหยี่ยวปีกแดง)	2	2	39	Decreasing	Non-migratory
Black-shouldered kite *Elanus caeruleus* (เหยี่ยวขาว)	20	49	44	Stable	Non-migratory
Common kestrel *Falco tinnunculus* (เหยี่ยวเคสเตรล)	3	10	106	Decreasing	Migratory
Sea eagle *Haliaeetus leucogaster* (นกออก)	1	1		Decreasing	Non-migratory
Brahminy kite *Haliastur indus* (เหยี่ยวแดง)	31	51	90	Decreasing	Non-migratory
Black eagle *Ictinaetus malayensis* (นกอินทรีดำ)	1	1		Decreasing	Non-migratory
Black kite *Milvus migrans* (เหยี่ยวดำ)	3	3	126	Unknown	Migratory
Blyth's hawk eagle *Nisaetus alboniger* (เหยี่ยวดำท้องขาว)	20	24	202	Decreasing	Non-migratory
Changeable hawk eagle *Nisaetus cirrhatus* (เหยี่ยวต่างสี)	23	24	178	Decreasing	Non-migratory
Wallace's hawk eagle *Nisaetus nanus* (เหยี่ยวหงอนสีน้ำตาลท้องขาว)	1	1		Decreasing	Non-migratory
Mountain hawk eagle *Nisaetus nipalensis* (เหยี่ยวผึ้ง)	2	2	576	Decreasing	Migratory
Oriental honey-buzzard *Pernis ptilorhynchus* (เหยี่ยวผึ้ง)	2	2	39	Stable	Migratory
Crested serpent-eagle *Spilornis cheela* (เหยี่ยวรุ้ง)	16	20	73	Stable	Non-migratory
Unidentified	2	3			

[a] Population trends and movement patterns according to the IUCN (IUCN, 2019).

during months March to May, the number of raptors offered for sale was significantly higher than that in the rest of the year ($\chi^2 = 37.76$, df = 1, $P < 0.0001$). We conducted comparisons of temporal analyses for trends in seasonality using the study by McClure and Chaiyaphum (1971), as it was the only study with detailed monthly accounts, which found more individuals in summer months from April to June.

Discussion

The trade in raptors is reported from 1960s until present time in Thailand, although the volume of species traded and means of trade have changed over time. Although the number of raptors observed has clearly reduced since the surveys conducted by McClure and Chaiyaphum (1971) compared with subsequent studies which report very few individuals and species, we now have an equal variety of species and large numbers offered online. In both models, wingspan (which is the proxy indicator for body mass) is consistently the factor which explains availability and price, where smaller birds were offered more frequently and also at lower prices. Although the numbers of raptors offered online are comparatively low, the sustained trade potentially poses a conservation threat to species if illegal trapping and harvesting of owls from natural populations remain unregulated.

Globally, raptor trade is increasing in volume, where 44% of the species reported for trade associated with a decreasing trend in the IUCN Red List (Panter et al 2019). The purpose for trade has now extended beyond traditional functions, such as falconry (Roldan-Clara et al 2014; Wyatt 2009; MaMing et al 2014), but appears to be traded for general exotic pet purposes. At the international scale, past records of irregular or illegitimate import–export trade documents have previously been an issue (Shepherd, 2012; Panter et al 2019). Domestically, there still needs to be increased studies on the impact of harvest on wild raptor populations as Thailand has been recognized as an important raptor migration site (Decandido et al 2004). Furthermore, it has been noted that domestic markets are often overlooked and underreported (Phelps et al 2010). The domestic trade of raptors recorded here is illegal under Thailand's wildlife laws, without government approved paperwork, none of which was offered.

Challenges

There are only a few studies that have directly compared the shift in wildlife market platforms. Bird markets in Indonesia are one of the places that have been thoroughly studied over time (Iqbal 2016, Gunawan et al 2017; Table 5). Iqbal (2016) monitored five specialized birds of prey Facebook groups for, on average, 8 months over 2015. Three of the five Facebook groups were based in Java (but of course people from outside this island are able to join and participate), and these were responsible for about two-thirds of the birds of prey that were offered for sale. Gunawan et al (2017) monitored 38 general wildlife trade and specialized birds of prey Facebook groups for 11 months over 2015, with about 90% of the offers originating from Facebook groups that were based in Java. In another study that monitored 15 bird markets in eight cities in Java from April 2014 to July 2019 (Nijman and Nekaris 2017; Nijman et al 2018) reported all birds of prey were openly offered for sale.

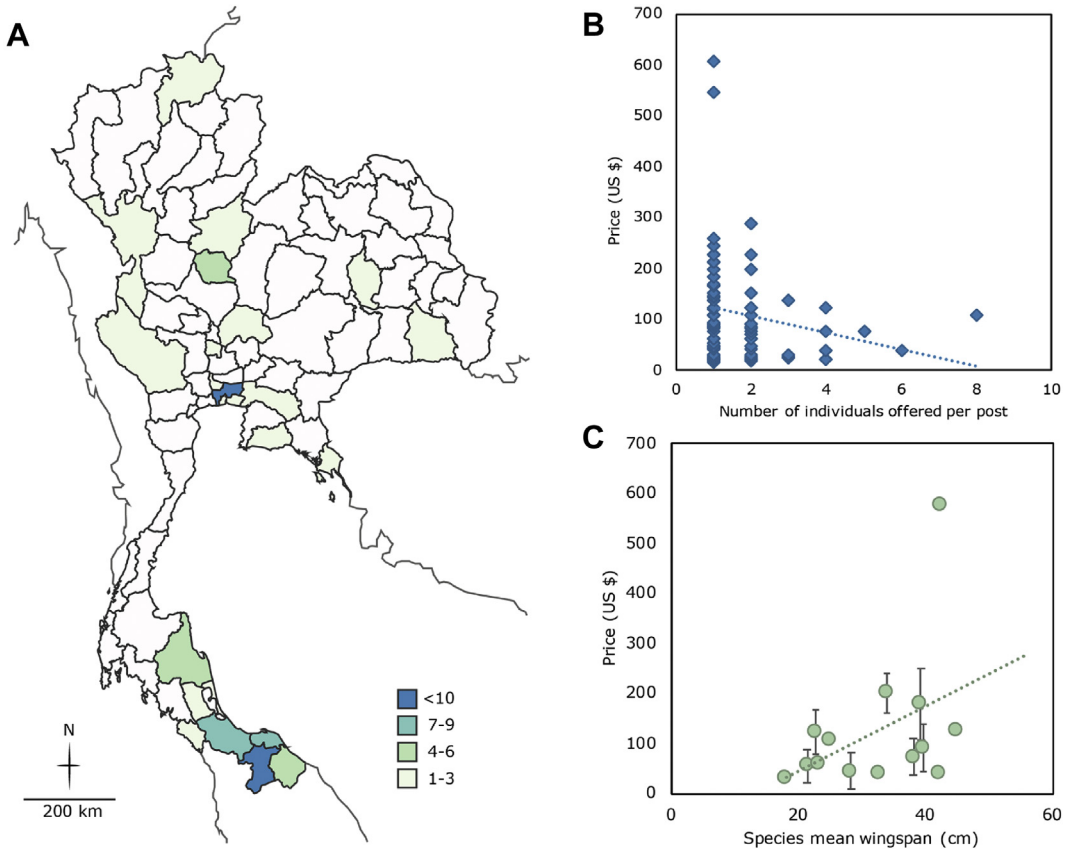

Figure 1. Geographic distribution of where provinces where posts originated in Thailand (n =23); four provinces were originated internationally, A. The number of individuals offered per post and prices offered per post, B. Wing span and price using mean values per species, C.

Despite differences in methodologies and survey efforts, we find similarities in species offered for sale, specially the migrant species which also fly over Thailand and mainland Southeast Asia such as the Japanese sparrowhawk *Accipiter gularis* and Chinese goshawk *A. soloensis*, as well as sales of nonmigratory species such as mountain hawk-eagles *N. nipalensis* which must have been imported from the mainland and Thailand are one of the closed source countries.

The shift of wildlife sold in physical markets to online markets goes beyond wildlife sold for the purposes of exotic pets. A key reason is the increased desire for the closure of wet wildlife markets for a variety of reasons. There is evidence that physical markets are used as platforms to trade both legal and illegal wildlife (Fischer 2004; Moyle 2017). The drive for the sale of high-value derivative wildlife products such as ivory to close markets is a high profile example aimed to reduce the poaching of African elephants. Another example is the push for closures of physical wildlife markets because of the risks as a potential source for zoonotic disease transmission (Karesh et al 2005). In 2002, the outbreak of a severe acute respiratory syndrome coronavirus in humans was linked to Himalayan palm civets (*Paguma larvata*) in wet markets in Shenzen, China (Webster 2004; Bell et al 2004). In 2019, an outbreak of a novel coronavirus (COVID-19), which causes respiratory illness, was linked to Huanan wet market in Wuhan, China (Li et al 2020). This consequence of the outbreak to the global economy has led many governments, including the Chinese government, to impose a ban on the trade and consumption of wild animals, with the exception of for medicinal purposes (Xinhua News 2020). Disease risks are also evident within the raptor trade, where traded raptors were found to be suseptible to, and carriers of highly pathogenic strains of H5N1 influenza virus. This was found in raptor species smuggled from Thailand to Belgium (changable hawk eagle; Van Borm et al. 2005; Steensels et al. 2007), in Japan (mountain hawk eagle; Shivakoti et al. 2010), and Saudi Arabia and Kuwait (saker falcons; Marjuki et al. 2009).

Table 4. Generalized linear model output scores and variables outputs.

Explanatory variable, Market platform	Model AIC Score	Wingspan	Clutch size	IUCN trend	Migratory status
(a) Price, Online platform	140.71	Wald $\chi^2 = 21.52$, df = 5, $P < 0.001$	Wald $\chi^2 = 27.51$, df = 3, $P = 0.001$	Wald $\chi^2 = 9.11$, df = 1, $P = 0.003$	Wald $\chi^2 = 5.28$, df = 1, $P = 0.022$
(b) Availability, Physical market	135.73	Wald $\chi^2 = 17.29$, df = 6, $P = 0.008$	Wald $\chi^2 = 4.42$, df = 3, $P = 0.22$	Wald $\chi^2 = 0.28$, df = 1, $P = 0.62$	Wald $\chi^2 = 0.13$, df = 1, $P = 0.91$
(c) Availability, Online platforms	168.95	Wald $\chi^2 =$. 38.07, df = 7, $P < 0.001$	Wald $\chi^2 = 10.05$, df = 4, $P = 0.04$	Wald $\chi^2 = 4.44$, df = 1, $P = 0.035$	Wald $\chi^2 = 1.07$, df = 1, $P = 0.30$

AIC, Akaike Information Criterion.

The examples mentioned indicate that the move toward online platforms is not only driven by choice and changes in consumer behavior, but it may also be the only option for some traders. The challenge to properly obtain data on what wildlife is being sold, the volumes and turnover rates and market dynamics are even harder to estimate when the trade goes underground. The important thing needed to identify a shift is thorough monitoring of both platforms to closely track it. Moreover, the same issues that follow physical markets of illegal items being laundered through legal trade platforms are still evident even among online market platforms (Gao and Clark 2014). However, law enforcement actions are not the same on both platforms. Traditional markets may require authorities going to shops that illegally sell such as city markets, border markets, trading hubs at ports, and stores. Online traders, on the other hand, are more flexible and traders do not necessarily need to have a pet shop. Conservative wildlife trade legislation in many places does not currently include the online trade. The potential threat remains that, if further bans of trade are extended onto online platforms, it may potentially even drive traders to go underground into the dark web and will pose further challenges for law enforcement agencies (Harrison et al 2016).

The function and role of social media platforms for trade also needs to be addressed. The link between the growth of social media and exploitation of threatened species for pet purposes is somewhat subjective but highlighted for the trade of raptors and owls (Kitson and Nekaris 2017; Panter et al 2019). Recently, more research is being dedicated to investigate the role and impact of social media on legal and illegal trade of birds (Iqbal 2016; Siriwat et al 2020) and other species (Martin et al 2018, Di Minin et al 2018). The combination of increased monitoring trade on these novel platforms, with continued surveying of traditional markets to ensure no increase in numbers are offered for sale, will be essential in helping inform wildlife regulations and policies, not only of raptors but of all wildlife species targeted for trade.

There is a growing body of literature that addresses the need for monitoring online platforms for wildlife trade. A multifaceted approach in monitoring, capacity development, and encouraging change in consumer behavior are key starting points (Aloysius et al 2019). Through tracking of trade volumes and prices, online trade data can also be used to develop a better understanding of markets, which can in turn be used to predict trends and set priorities for conservation (Harris et al 2015). Furthermore, illegal activity online can also provide the opportunity with accessible data to assess consumer behavior, which can ultimately be integrated into conservation management strategies (Sung and Fong 2018).

Conflict of interest

The authors declare that there is no conflict of interest.

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