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REVIEW PAPER

Comparisons of songbirds on sale across online and physical markets in Indonesia

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Abstract

Unsustainable wildlife trade is a leading threat to biodiversity, not least in Southeast Asia where serious overexploitation of songbirds has precipitated the 'Asian Songbird Crisis'. While the nature of bird trade in physical markets is fairly well studied, the growing online trade in birds is far less understood, in terms of diversity and traits of birds on offer. Here, online trade, monitored across twelve broad spectrum Indonesian bird-selling Facebook groups over a period of six months in 2022, is compared to published data from physical markets, and from a machine learning web-scrape. Nearly 2,000 individuals of 190 Indonesian species were recorded from Facebook, with 9.5% of species being categorised as Threatened (IUCN 2022), 15.8% protected under Indonesian law, and 17.4% regarded as priority taxa according to the Asian Songbird Trade Specialist Group. These represent similar proportions of species to those from physical market surveys, although physical markets had more individuals of protected species than did Facebook groups. Bird family composition did not correlate between online and physical platforms, with the former dominated by Muscicapidae and the latter by Estrildidae. Controlling for trade volume, online groups had higher species richness than physical markets, although the difference was not significant. Bird 'communities' on offer in the individual Facebook groups were both similar to each other, and distinct from those in physical markets, although there was a geographical signature especially in the latter. Results highlight the importance of monitoring online trade as, while there are substantial differences in types of birds sold, it contains a similarly high number of species of conservation concern to physical markets.

Keywords Asian Songbird Crisis · Bird families · Facebook · Internet · Wildlife trade

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Introduction

Exploitation for domestic and international trade is one of the biggest threats to birds worldwide (Leupen et al. 2022a). This is especially prevalent in Southeast Asia, where keeping birds is deeply entrenched in local culture (Marshall et al. 2021), particularly with songbirds. Such is the perceived problem of over-exploitation of songbirds, that the issue, widely known as the "Asian Songbird Crisis" (ASC; Marshall et al. 2020a) has resulted in many species being classified as Threatened by the IUCN Red List (IUCN 2022). Central to the ASC is Indonesia generally, and Java specifically, where Marshall et al. (2020a) estimated there are 36 million households keeping 70 million birds, around 31% of which can be described as Southeast Asian passerines. Species such as White-rumped Shama (*Copsychus malabaricus*), Orange-headed Thrush (*Geokichla citrina*) and the leafbirds (Chloropseidae) are much sought after for songbird competitions (Angguni et al. 2021), while the general songbird trade means that in Java alone approximately 1.4–1.8 million birds may be removed from the wild annually, in order to supply demand (Nijman et al. 2017).

Although currently 557 species are considered legally protected from any trade under the Regulation of the Minister of Environment and Forestry no. P.106/MENLHK/SETJEN/KUM.1/12/2018, regulations are seldom enforced (Shepherd and Leupen 2021) and birds are openly traded in most towns and cities (Chng et al. 2015, 2018a, b; Iskandar et al. 2019). Birds have, for decades, been traditionally sold in large public markets such as Pramuka bird market in Jakarta or smaller bird markets and shops in the provinces. There have been efforts to monitor trade at these markets over the years, which while not ideal in that they measure 'stock' rather than 'throughflow' of birds, have yielded valuable data on trade volume and trends (Chng et al. 2015, 2018a, b; Iskandar et al. 2019; Shepherd and Leupen 2021; Leupen et al. 2022b).

The growth of the internet has enabled a significant level of wildlife trade to occur as an alternative platform to physical markets (Lavorgna 2014). Online trade encompasses diverse groups of species including mammals (Kulkarni and Minin 2023), birds (Nijman et al. 2022), plants (Hinsley et al. 2015), and reptiles (WWF 2017). Despite emerging evidence that online wildlife trade furthers the selling of illegal species (Sung and Fong 2018), there is a lack of data to properly assess the extent and trends of species found (Nguyen and Willemsen 2016). One area where there is a paucity of data is regarding online trade in Indonesian songbirds, and comparisons to physical markets (Nijman et al. 2022). Indonesia is home to a large number of internet users, with approximately 129 million Facebook users registered in January 2023, making it the third largest user in the world (Statista 2023). Facebook has many online selling groups devoted to songbirds and songbird-related products, with some amassing thousands of members (Table 1). The few studies to have examined the Indonesian online trade have focused on raptors (White and Panter 2020; Nijman et al. 2022), or were restricted to just a handful of species (Fink et al. 2021), and did not make comparisons to physical markets (Iqbal 2015; Okarda et al. 2022).

The aim of this study was to examine the diversity of birds on sale across a number of online Facebook groups and to compare species richness, family composition, and presence of conservation-priority species with those on sale in physical bird markets. The study data, and wider research (Nijman et al. 2017) suggests vast majorities of bird trade in Indonesia comprise songbirds (Passeriformes), therefore, are the focus of this study. We also compare the differences in bird composition of the Facebook survey with that of a recently published

article that used machine learning models to identify birds being sold in online advertisements (Okarda et al. 2022).

Methods

Study design

The online survey focused on twelve Facebook groups (Table 1) based in Indonesia, selling a variety of songbirds. We chose Facebook groups that were large in terms of numbers of members, active in terms of frequency of bird-selling posts, selling primarily songbirds and, as far as possible, representative of the large number of 'broad-spectrum' bird-selling Facebook groups currently active. These groups were chosen through keyword searches of Indonesian species names. After becoming a member of one or two groups Facebook recommends more similar groups meaning the network can grow automatically, therefore, the rest were selected via snowball sampling. Some groups required approval to enter, however, most were public and simple to join. We avoided Facebook groups that specialise in individual taxa (e.g. Pecinta Burung Cucak Ijo Indonesia (PBCI; www.facebook.com/groups/709119985944530) which focuses on Greater Green Leafbirds (*Chloropsis sonnerati*)). Three of the original groups were closed down during data collection, several also stopped posting so were replaced with substitutes, through Facebook's recommendations of similar groups (Table 1). The high number of Facebook groups were due to replacements being deleted or becoming inactive resulting in them being re-replaced. Five Facebook groups were monitored at least four days a week (unless issues arose) over a six-month

Table 1 Summary information of Facebook groups visited with missing data from deleted groups. * deleted; +inactive; groups used in community analysis are labelled FB and given a number in order to distinguish the groups

	Main location	Number of members	Date created	Period of data collection	Survey days
Burung langka Indonesia (Buli) (FB2)	East Java	11,975	26/07/17	05/04–05/10	168
Komunitas Pecinta Burung Berkicau di Bali (FB5)	Bali	17,197	27/06/14	05/04–05/10	168
Komunitas Penghobi Kicauan Jakarta Selatan+ (FB6)	Jakarta	21,704	01/08/20	05/04–23/08	130
Pecinta burung kicau Palembang* (FB7)	South Sumatra	-	-	05/04–10/08	118
Kicau burung krian sepanjang sukodono* (FB4)	East Java	-	-	05/04–08/08	115
Burung Kicauan Daerah Sidoarjo (FB1)	East Java	35,153	18/11/18	16/08 – 05/10	49
Grup burung kota Bogor dan kabupaten* (FB3)	West Java	-	-	13/08–28/09	46
Pecinta Burung Bawean	-	3,111	05/11/19	15/09 – 05/10	20
Pecinta Burung Kicauan Pontianak	West Kalimantan	6,470	07/08/20	19/09 – 05/10	16
Grup Burung macam jember*	East Java	-	-	30/08–15/09	15
Burung kicau Depok Bogor*	West Java	-	-	12/08–15/08	3
Perawatan burung Kolibri Ninja (Konin) Indonesia+	West Java	77,437	30/08/17	12/08	1

study period (5 April to 5 October 2022). Posts were sorted chronologically and the newest six posts in each group that had songbirds for sale were identified. Six posts a day were chosen arbitrarily and under the time constraints was considered a sufficient sample size. For each post, a photograph of the bird advertised was saved for identification, group size recorded, along with any details of location and the date was collected. Any duplicate posts (usually reposted in other groups) were included only once in the dataset, whereby the first Facebook group the species was mentioned in was kept and the others were ignored or discarded.

We restricted our study to Indonesian songbirds (Passeriformes) that are often kept as caged birds (see Table S1 for full list). Some birds were identified by using information from the Facebook post and consulting authoritative regional field guides (Strange 2012; Pratt and Beehler 2015; Eaton et al. 2016). Identifications were then verified by SM, JM, and other ornithologists with strong regional experience. Some birds in some posts could only be identified to genus, especially poor-quality photos of female sunbirds (Nectariniidae), leafbirds (Chloropseidae), and prinias (Cisticolidae). Remaining posts that could not be identified were discarded - these mainly consisted of poor-quality photos and nestlings. For each species, we recorded its protection status (Ministry of Environment and Forestry of The Republic of Indonesia 2018), whereby all trade in the species is illegal by Indonesian law. We also recorded each species' IUCN Red List (IUCN 2022) classification and whether it appears on Tier 1 (Conservation priority) or Tier 2 (Watch list) of the Asian Songbird Trade Specialist Group (ASTSG) 2022; www.asiansongbirdtradesg.com/taxa-list.

Comparisons with physical market and other studies

Data on physical markets were collated from four published recent large bird survey studies conducted in Indonesia (Chng et al. 2015, 2018a, b; Iskandar et al. 2019; Table 2). These Facebook groups were also selected based on location, so that the location of the studies correlated to the most numerously named locations stated in the Facebook posts.

As an additional comparison, a study containing high volumes of data from a machine learning model was used (Okarda et al. 2022). The study was also conducted online, and collated species data from online adverts selling birds from Indonesian sellers. The tool detected adverts that were selling birds from April 2020 to June 2021, obtaining 284,111 songbirds of 250 species. The MLM (Machine Learning models) scraped adverts from across Indonesia but we argue that it is comparable with our Facebook and physical market data (restricted to Western Indonesia) because the latter is the centre of bird ownership in the

Table 2 Published studies on physical bird market surveys in Indonesia that provided data to compare with online markets

Markets	Location	Year(s) of Survey(s)	No. of birds	Reference
Sukahaji; Bandung; Splendid; Malang;	West and East Java	2015	6,508	Iskandar et al. (2019)
Pramuka; Jatinegara; Barito	Jakarta	2014	19,036	Chng et al. (2015)
Pasar Burung Sanglah; Pasar Burung Satria	Bali	2017/18	12,486	Chng et al. (2018a)
Jambi; Medan; Paembang; Pekanbaru	Sumatra	2017	7,269	Chng et al. (2018b)

country, and a hub of trade for birds from elsewhere in Indonesia and beyond (Nuruliawati et al. 2023).

Any bird species that were outside of the scope of the online survey were also removed from the physical and MLM dataset, including any that were hybrids, exotic or domesticated species. When comparing individual Facebook groups to physical markets and selling site data, the seven Facebook groups with the largest amount of data were selected for further analysis. The remaining Facebook groups were discounted due to the low counts of birds therefore would not have been a fair comparison.

Data analysis

A Chi-squared test with Yates' correction was conducted to assess if there was a significant difference between the number of protected species found online versus in physical markets. A similar test was used to compare the numbers of species listed as Threatened (including Vulnerable, Endangered and Critically Endangered), and to compare priority taxa in Tier 1, and Tier 1 and 2 combined. To test for differences in the relative abundances of protected species within the Facebook groups and physical markets, we first calculated the proportion of the total samples of birds that were made up of each protected species in each platform. We then performed a Mann-Whitney U test on these proportions across the two platforms and repeated the test for threatened and ASTSG priority species. To identify the degree of correlation between bird family compositions of online and physical markets, a Pearson correlation analysis was performed. To compare bird species richness on offer across online markets, physical markets, and the machine learning study, we regressed the number of species in each individual market and selling group against the log10-transformed number of individual birds for sale. Next we tested for normality using the Shapiro-Wilk test, this showed a normal distribution ($W=0.924,\ p=0.23$). Therefore we tested to see if residuals from this regression differed between online and physical markets using a t-test.

To examine similarities and differences in bird communities on sale across individual Facebook groups, individual physical bird markets and the machine learning data, we used non-metric multidimensional scaling (NMDS). For each online and physical market we used the number of individuals of each species on offer, as the input into the NMDS -These make up our bird communities. An ANOSIM was run to test if there was a significant difference between each community. Data analyses were all conducted in R Studio version 4.2.1 and R studio version RStudio 2023.06.1+524 (R Core Team. 2022).

Results

Facebook online trade

Over the six-month period, 2,371 posts selling 1,884 individual birds, comprised of 176 species from 42 families were identified across the seven Facebook selling groups (Table S1). The most frequently found bird species were White-rumped Shama (*Copsychus malabaricus*) (27.1% of all individual birds recorded), Oriental Magpie Robin (*Copsychus saularis*) (8.8%) and Long-tailed Shrike (*Lanius schach*) (5.8%). Thirty (17%) of the species recorded were listed as protected under the Ministry of Environment and Forestry of The

Republic of Indonesia (2018). These included Greater Green Leafbird (*Chloropsis sonnerati*), Bali Myna (*Leucopsar rothschildi*) and Javan Green Magpie (*Cissa thalassina*). The proportion of species listed as Threatened is 10.2% and the number of individual birds is 11.4% on the IUCN Red List (IUCN 2022). Additionally, 11.4% of species and 46.6% of individuals are categorized as a Tier 1 and 7.4% of species or 6.8% of individuals as Tier 2 priority taxa by the ASTSG.

Comparisons across bird-selling platforms

There was a no significant correlation between family composition of birds for sale across the online selling groups and physical markets ($r=+0.17$, $df=46$, $p=0.253$). While proportions of families, in relation to individual number of birds, such as starlings Sturnidae (*online: 10.2%, physical: 7.2%*), and bulbuls Pycnonotidae (*online: 9.1%, physical: 10.3%*) and leafbirds Chloropseidae (*online: 9%; physical: 10.7%*) were similar, proportions of other families differed markedly (Fig. 1). Online trade included far bigger proportions of flycatchers Muscicapidae (*online: 37.7%; physical: 5.2%*), as well as thrushes Turdidae and crows Corvidae, while physical markets were dominated by finches/munias Estrildidae (*online: 0.1%; physical: 37.3%*) and White-eyes Zosteropidae (*online: 2.5%; physical: 13.2%*).

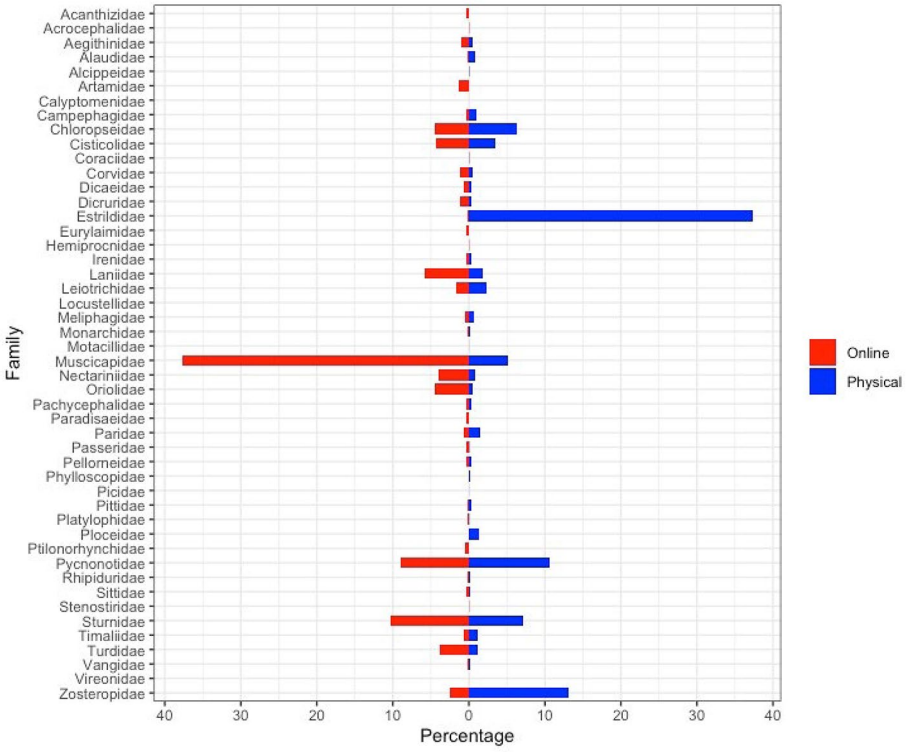

Fig. 1 Percentages of individuals in online (left) and physical (right) markets belonging to each passerine bird family, set out back-to-back in order to compare the proportion in each platform

Species identified as being of conservation concern, either on the IUCN Red List (IUCN 2022) or by ASTSG did not differ significantly between platforms (Table 3). Numbers of Protected species (x^2=*0.5 df=1, p=0.48*), Threatened (x^2= *0.06, df=1, p=0.81*), ASTSG Priority Tier 1 (x^2= *0.09, df=1, p=0.76*) or Tier 1 and 2 combined (x^2= *0.17, df=1, p=0.68*) did not differ significantly between online and physical markets. In terms of relative abundance of birds within the samples, there were no significant differences across platforms for Threatened species (*z=0.98, p=0.33*), ASTSG Priority Tier 1 (*z=1.35, p=0.18*) and Tier 1 and 2 combined (*z=1.32, p=0.19*), but Protected species had greater relative abundance in the physical markets than the Facebook groups (*z=2.96, p<0.01*).

Figure 2 shows, for each Facebook group and physical market, and the MLM model, the relationship between number of species for sale and total individuals for sale (log10). Points appearing above the line have higher than expected richness for a given volume of trade. Despite a small sample size, there was a near significant difference in residuals (*t=1.89, df=11, p=0.08*), with Facebook groups tending to have mean positive ($\bar{x}$ = *+9.35*) and physical markets negative ($\bar{x}$ = *-9.44*) residuals.

An ordination of Facebook groups, physical markets and the MLM model (Fig. 3) shows both quite distinct separation of the two main platforms, and quite tight clustering of the individual Facebook groups. There was a significant difference found between communities (*ANOSIM R=0.472, p*<0.001). Physical markets seem to be more varied in their bird compositions, and appear to be closer allied to the MLM model than to the Facebook groups monitored here. Additionally, the physical markets closer in location are broadly also found more closely situated on the NMDS. In comparison to temporally, where there seemed to be no particular pattern, with the oldest physical market data being closely found to the more recently collected market data.

Discussion

Important insights into wildlife trade can be gained from monitoring different selling platforms (Aloysius et al. 2019; Siriwat and Nijman 2020), with much research focusing on physical markets (e.g. Shepherd 2006, 2011; Chng et al. 2015, 2018a, b; Chng and Eaton 2016; Shepherd et al. 2016; Nijman et al. 2017; Rentschlar et al. 2018; Bergin et al. 2018; Iskandar et al. 2019; Shepherd and Leupen 2021; Putri et al. 2021; Leupen et al. 2022b). Comparatively, there have been few studies looking at online trade (Iqbal 2015; Fink et al. 2021; Okarda et al. 2022). Our study looked to characterise the online trade with focus on songbirds, and to compare with those on sale at physical markets. We found a higher species richness within the Facebook selling groups, for a given volume of birds sold, than in

Table 3 Number of bird species categorized as Protected (Ministry of Environment and Forestry of The Republic of Indonesia 2018), Threatened (IUCN 2022) or listed as a Priority Taxa (IUCN SSC Asian Songbird Trade Specialist Group 2022) in online and physical markets

	Online Market	Physical Market
Number of species	176	222
Number of protected species	30	31
Number of IUCN threatened species	18	20
Number of Priority taxa tier 1 species	20	22
Number of Priority taxa tier 2 species	13	15

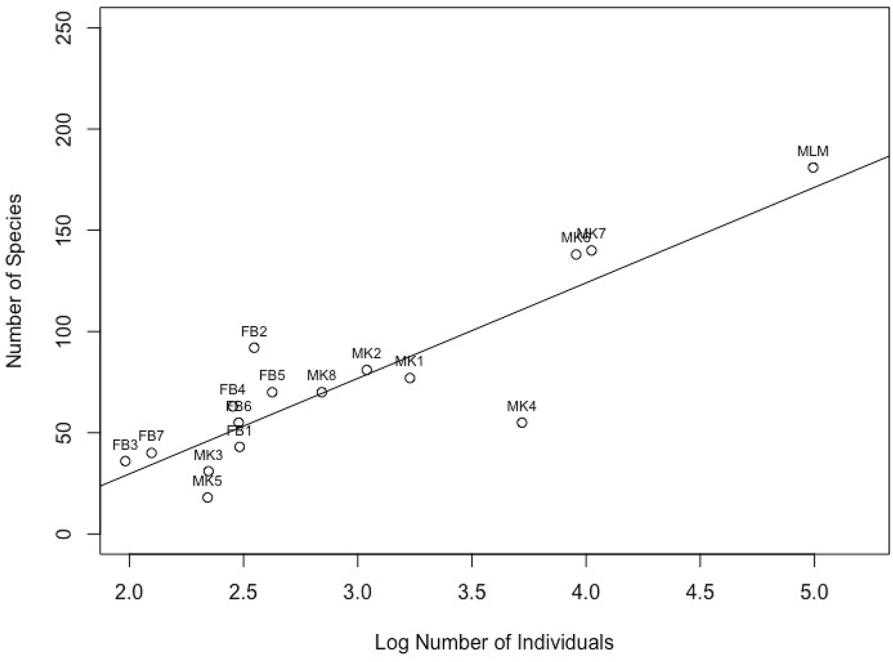

Fig. 2 Number of species in each Facebook group, individual market and machine learning model data plotted against the number of individuals log transformed with a line of best fit. (FB = Facebook group, MK = physical market, MLM = machine learning model)

physical markets, but, the difference was not significant. While there was a large proportion of threatened, protected, and conservation priority species for sale online, this was no more than that in physical markets, although the latter did have a higher relative abundance of protected species. It may be that some online trading groups are hotbeds of particularly rare, valuable and endangered taxa, as found elsewhere (Krishnasamy and Stoner 2016) but our Facebook groups acted similarly to physical markets. Some unprotected species still have an annual harvest quota (Government Regulation No.8/1999 on Wild Flora and Fauna Exploitation) for trading of wild individuals, whereby if its exceeded, further trade is prohibited, therefore they enjoy some level of protection. Importantly, the communities of birds for sale differed markedly across platforms, with a distinct spatial separation found between Facebook and physical markets. For example, the physical markets were largely comprised of Estrildidae and had a larger number of white-eyes comparatively to online trade. This concurs with Leupen et al. (2022a) findings who believes this is due to both having low monetary value and the target audience of the species, as White-eyes most commonly appeal to older men that would most likely prefer the traditional, physical markets. However, it contrasts with the findings of Siriwat (2020) who found no significant difference between species composition of a range of taxa between physical markets and Facebook selling groups. However, this study had a smaller focus group centring only on birds of prey, therefore likely having different trade dynamics driven by taxon-specific demand attributes and fewer species on offer.

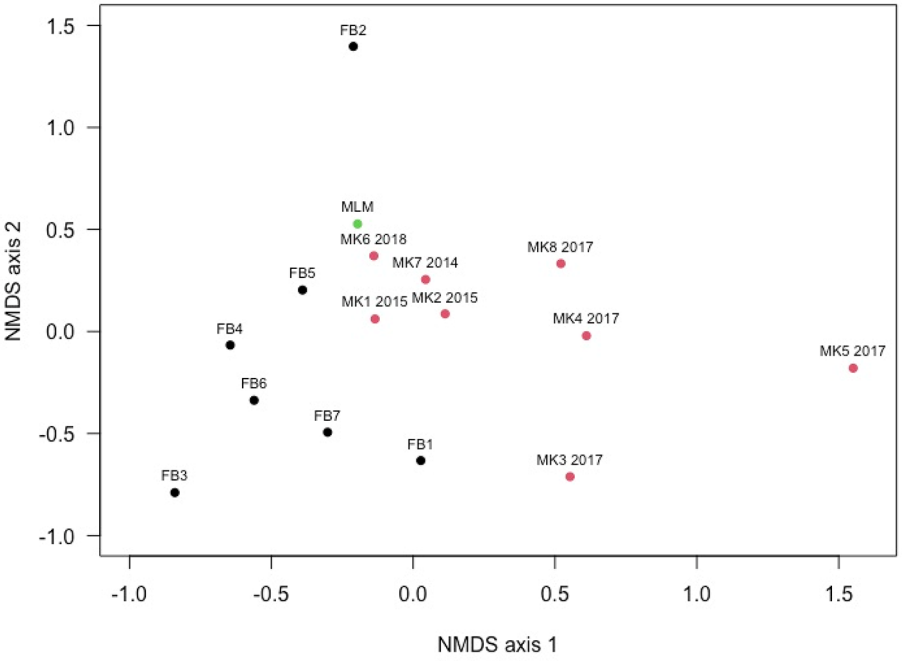

Fig. 3 Non-metric multidimensional scaling (NMDS) ordination of individual bird communities on sale across platforms. FB = Facebook; MK = Physical Market; MLM = Machine Learning Model. FB1 = Pecinta Burung Kicau Palembang; FB2 = Burung Lanka Indonesia (BULI); FB3 = Burung Kicauan Daerah Sidoarjo; FB4 = Kicau Burung Krian Sepanjang Sukodono; FB5 = Komunitas Pecinta Burung Berkicau Di Bali; FB6 = Komunitas Penghobi Kicauan Jakarta Selatan; FB7 = Grup Burung Kota Bogor Dan Kabupaten; MK1 2015 = East Java; MK2 2015 = West Java; MK3 2017 = Sumatra; MK4 2017 = Sumatra; MK5 2017 = Sumatra; MK6 2018 = Bali; MK7 2014 = Jakarta; MK8 2017 = Sumatra

Recent years have seen a movement away from traditional brick-and-mortar markets to the virtual marketplace (Lavorgna 2014; Siriwat and Nijman 2020). This shift has been observed across multiple countries (e.g. China: Yu and Jia 2015, Thailand: Siriwat and Nijman 2020, Vietnam: Leupen et al. 2022a) and taxa (e.g. wild cats: Nijman et al. 2019, reptiles: Marshall et al. 2020b, raptors: Siriwat 2020, mammals: Thomas et al. 2021). This change may be due to escalated enforcement in physical markets (Siriwat and Nijman 2020) – for example, the trade of Indian Star Tortoises *Geochelone elegans* in Malaysia was found to have significantly decreased in markets and pet shops while increasingly larger numbers are being advertised for sale on online platforms (Chng and Bouhuys 2015). The worldwide pandemic of the COVID-19 coronavirus increased awareness about the danger of animal markets in spreading zoonotic diseases and was likely to have accelerated the movement away from physical markets to online trade (Wittig 2020). These online platforms enable sellers to more easily reach a wider audience and give the option for anonymity (Lavorgna 2014; Yu and Jia 2015).

The important question is how much we should be concerned about online trade in Indonesian songbirds as compared to that in physical markets. In our study, species richness did differ significantly between online and physical market-based trade, with several Facebook

groups offering greater than expected species numbers given their overall traffic (Fig. 2). Similarly, Toomes et al. (2023) found high diversity in the online pet trade in Australia, especially among threatened taxa. While our Facebook groups certainly offered threatened and illegal birds, they did so in similar proportions to the physical markets and, in this respect, we suggest these online platforms are acting as extensions of physical markets. This concurs with Sung and Fong (2018) who found that species diversity of turtles being sold online was comparable to that found in physical stores. But perhaps not with Nijman et al. (2022) who found differences in the sizes of birds of prey found on sale in online and physical markets in Indonesia, where typically smaller birds were found being sold in the markets and larger species found online.

Our study aimed to compare bird communities across platforms, not to quantify the volume of online trade. This is a huge task, as seen by the number of active Facebook selling groups found online when replacing deleted groups during this study (see also Iqbal 2015). The groups chosen were large, broad spectrum groups, but only captured a tiny proportion of online trade, and explicitly excluded Facebook groups that focus on specific taxa (e.g. Crested Jay *Platylophus galericulatus*: Komunitas Cililin Indonesia - www.facebook.com/groups/2385504398388102). A considerable volume of trade is done on private Whatsapp groups and other platforms (Wyatt et al. 2022). For example, there has been a shift in online mammal trade away from Facebook, with primates appearing in WhatsApp groups recently showing a ten-fold increase over that openly traded in Facebook (J. Menner *pers. obs*). This is likely happening as mammals and primates are recognised by Facebook's mechanisms to combat trade, in comparison to WhatsApp, where there is an apparent oversight. This does not yet apply to birds as currently the awareness of illegality or illegitimacy is not as prominent as in primates, therefore means they are less likely to be banned (J. Menner *pers. obs*). Finally, trade on the dark web, although at present appearing far less important in terms of volume than other platforms (Harrison et al. 2016; Stringham et al. 2023) this may change of course, especially if policing of current platforms becomes stricter (Stringham et al. 2023). Our study relied on manual checking of bird-selling posts and identification to species, but use of AI bird identification could allow for much greater samples of posts to be scrutinised. Web scraping software would also be a useful tool for monitoring online trade on websites that allow it, (Stringham et al. 2020; Mutiaradita et al. 2023), however, this is prohibited on Facebook. Preliminary data on AI cagebird identification in Indonesia suggest good accuracy rates (Shukhova et al. 2022) and it is likely that this technology will allow for faster identification and therefore more widespread monitoring of online platforms used for trade. Interestingly, the machine learning web-scraping model considered in our comparisons (Okarda et al. 2022) contained a very low species number given its huge sample of individual bird posts. It may well be that automated approaches harvest large amounts of data but lack, at present, the resolution to identify difficult taxa to species (e.g. *Zosterops*) or simply miss rare but important taxa (Stringham et al. 2020; Hachemin 2023). In our ordination, the machine learning model, based on adverts from dedicated bird-selling internet sites, had a bird community more similar to the physical markets than to our Facebook groups suggesting some degree of niche or specialism within some Facebook communities (Siriwat and Nijman 2020). Additionally, the physical markets showed some clustering based on their geographic location, with markets in closer physical proximity being found more similar, shown on the NMDS model. Useful tools are emerging for large scale moni-

toring of both physical and online trade in Indonesian songbirds and other wildlife (Cardoso et al. 2023).

Interestingly, there does not seem to be any tendency for the older physical market surveys to be 'outliers' in terms of their bird communities. In fact, the markets that clustered closest to each other and to the Facebook groups include both older and newer markets. It is expected that there will be temporal changes in bird occurrence in markets over the years (Tella and Hiraldo 2014), as also evidenced by recent large numbers of confiscations of Cisticolidae (birds not usually found in markets in great numbers) in Sumatra and Java (Guciano et al. 2023). With these points in mind, we must interpret our comparisons between online and physical markets cautiously.

Our results highlight the heterogeneity in bird communities offered across platforms and geographies, differences that may also be mirrored seasonally or annually, and in response to bird availability, demand, and reaction of the trade to enforcement efforts (Tella and Hiraldo 2014; Xu et al. 2020).

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10531-024-02825-w.

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Author contributions EG, JM and SM conceptualised and designed the project. The groups used for data collection were identified by JM. EG collected data and ran statistical analyses with SM. EG and SM both contributed to writing the manuscript with added inputs from JM. All authors have read and approved the manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Supplementary information We have included the Appendix table (Table S1), which depicts all the bird species collated and used in the analyses of this paper. It includes their common name, Scientific name, their quantity, Protection status (Ministry of Environment and Forestry of The Republic of Indonesia 2018), IUCN Red List (IUCN 2022) classification and whether it appears on Tier 1 (Conservation priority) or Tier 2 (Watch list) of the Asian Songbird Trade Specialist Group (ASTSG) 2022; www.asiansongbirdtradesg.com/taxa-list. These were all sorted by where the data was obtained.

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