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Surveys of live bird markets in China: Revealing patterns to inform policies

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ABSTRACT

Survey of live bird markets is a useful way to support conservation and enforcement efforts by providing first-hand information on bird trade. There is a lack of surveys of bird markets across China after the pandemic outbreak and introduction of new regulations. We surveyed 12 selected physical bird markets in 2021 and 2022 to explore their characteristics and changing trends with comparison to a previous survey of the same 12 markets in 2016–2017. The total number of birds recorded in the 12 markets was similar in the two surveys, but the number of wild bird species and individuals decreased by 40% and 75%, respectively. The proportion of wild birds decreased from 49% to 13%, while that of captive-bred birds, dominated by Psittaciformes birds, increased from 51% to 87% between the two surveys. Thirty-one species with conservation concerns were observed for sale in the markets, warranting close monitoring and enhanced enforcement of the markets. Larger markets tended to have a lower proportion of wild birds possibly due to a better management model, and the number of recorded birds and species varied seasonally with the largest numbers in the autumn/spring season. Targeting combats against illegal bird trade in the autumn when wild bird trade is booming may be more cost-effective. There is a need to continue monitor and survey physical bird markets and other platforms to better understand the markets for sustainable bird trade. Furthermore, the bird composition and trade volume of the markets could reflect public demands for birds as pets, and how to balance meeting the public demands and protection of the wild bird populations remains a challenge. Reducing demand for wild-sourced birds and regulated use of captive-bred birds with large wild populations as substitutes could be an option.

1. Introduction

The wildlife trade is a long-established and highly profitable industry which is a considerable income source for many underdeveloped countries or regions in the world (Hughes et al., 2023; Ribeiro et al., 2019; Shairp et al., 2016). Birds are the most affected group of vertebrates by the wildlife trade, involving over 4500 species (44.5% of 10,278 species) across the world (Scheffers et al., 2019). Africa, Latin America, South-East Asia and parts of East Asia are hotspots for bird trade, and these regions have high bird diversity, cultural traditions of bird-keeping and even economic reliance on bird trade (Neto et al., 2022; Scheffers et al., 2019). Population growth, poor management, and limited public awareness in these regions have contributed to the overexploitation of wild bird populations, leading to many ecological and social problems such as increasing risk of species extinction, spread of infectious diseases, and even regional crime (Daszak et al., 2000; Smith et al., 2009; UNODC, 2020). However, legal wildlife trade, including captive breeding of wildlife, if properly managed and regulated, could help to alleviate the pressure on survival of wild populations and sustainable development (Tensen, 2016; You, 2020; Zhang et al., 2024). Therefore, understanding the impacts of wildlife trade is essential for assessing its threats to species, balancing ecological conservation and economic development, and formulating regional, national and international policies.

Due to the challenges and high cost of comprehensive and systematic monitoring of wild bird populations, the trade demand and trade trends reflected by surveys of bird markets can provide valuable information on the status of wild bird populations, which is in turn of guiding significance for the conservation of wild bird populations and the development of bird captive breeding industry (Bušina et al., 2021; Harris et al., 2015; Irham et al., 2019). The quantitative and qualitative data gathered from surveys of bird trade in the street markets in Recife of Brazil underscore the critical impact of street markets as wildlife sinks on wild bird populations (Regueira and Bernard, 2012). Field surveys of bird markets and pet shops in major cities of Singapore and Vietnam have revealed the dominance of native species in bird markets and the potential impact

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on local wild bird populations (Leupen et al., 2017; Eaton et al., 2017). Indonesia is regarded as the hotspot of the Asian songbird crisis, and the data collected from live bird markets, online platforms, and dealers through years of market research systematically depict the entire picture of the bird trade in Indonesia, providing a comprehensive data basis for understanding and predicting the market and population trends, as well as for conservation efforts (Leupen et al., 2020; Nijman et al., 2021, 2022).

China is rich in wild bird species, with a long history and culture of appreciating and keeping birds as pets, and there is a historical, social and cultural basis for the associated bird markets (Dai et al., 2021; Leung, 2022). China is home to nearly 60 endangered bird species, and some migratory birds, such as the Yellow-breasted bunting (*Emberiza aureola*), are on the verge of extinction due to capture for trade (Lees and Yuda, 2022). Four major global migratory bird flyways pass through Chinese territory, leading to peaks of illegal bird capture and trade during the migratory season, posing a considerable threat to wild bird populations (Kamp et al., 2015).

The bird markets in China serve for three major functions, i.e., pets, food (tonic), and religious releasing, and thus involve a wide range of stakeholders such as trappers, breeders, intermediaries, sellers, buyers, etc. Previous studies have found that the bird markets have continued to expand with China's growing GDP (Ni et al., 2022; Shiu and Stokes, 2008), and that the majority of birds traded in the markets are wild-caught migratory birds with clear seasonal fluctuations (Bi and He, 2005; Dai and Zhang, 2017; Li et al., 2019; Wang et al., 2021). An investigation into the bird markets in Guiyang City in China reveals the possible impacts of bird trade on conservation, as well as other potential risks such as biological invasions and disease transmission (Dai and Zhang, 2017). Studies of bird markets in Guangzhou City have shown that the areas with active bird trade are often associated with intensive wild bird capture activities, highlighting the strong linkage between wildlife market monitoring and wild bird population conservation (Fiennes et al., 2021).

Although there have been a few surveys of live bird markets in China, most of them have been sporadic and localised to a particular area (e.g., Dai and Zhang, 2017; Li et al., 2019). Only one nation-wide survey of physical bird markets in China was so far conducted in 2016–2017 by the Kunming Vermilion Bird Ornithological Institute (KVBOI) (KVBOI, 2018). The 2016–2017 survey involved over 200 bird markets in 30 provinces across the mainland China, and recorded a total of 240,406 individual birds belonging to 474 species, among which 392 were wild bird species, totalling 117,136 individuals (KVBOI, 2018).

After the outbreak of the Covid-19 pandemic in the early 2020, Chinese government has implemented several new policies regulating or even banning wildlife trade and consumption for food (You, 2020; NFGA, 2021a,b). For example, the Decision issued by the Standing Committee of the National People's Congress in February 2020 prohibits consumption of wildlife (for food) including captively bred wildlife and prohibits hunting, trading or transporting of terrestrial wildlife for the purpose of consumption (for food) in order to protect the human health and lives for an undefined period (NPC, 2020a). The list of State Key Protected Wild Animals (Class I and Class II) was updated and revised in the early of 2021 with an addition of 150 bird species (NFGA, 2021a), offering greater level of protection for those listed birds (Xiao et al., 2024). Although it is reported and anticipated that there have been major changes and reduced bird trade volumes in the wildlife markets after the pandemic outbreak and these policy changes, no attempts have been undertaken to assess the status of bird markets across the country.

The lack of timely and comprehensive investigations into the physical bird markets in China has implications for bird conservation, policy development, and management of bird trade. To understand the patterns of bird trade following regulatory changes and the pandemic outbreak, we conducted a survey of typical bird markets in China using a comparable method with the survey in 2016–2017. It elucidated bird market size, species composition, trade dynamics, and seasonal variations in bird species and quantity in the markets, and we proposed corresponding recommendations for managing bird markets and informing the development of bird captive breeding industry and of sustainable bird trade in China.

2. Methods and materials

In order to compare with the survey 2016–2017 which surveyed over 200 bird markets across the country, we used the same methodology (KVBOI, 2018; Liang et al., 2024) to collect data from selected bird markets from September 1, 2021 to September 30, 2022, and all surveyors were familiar with the methodology and participated in both surveys.

We performed a pre-survey to determine appropriate bird markets to be surveyed and human resources needed for this survey. Our pre-survey revealed that many bird markets covered by the 2016–2017 survey were shut down during the pandemic, and even for the still-existing markets, many of them had only sporadic bird trade with negligible trade volume of birds.

Thus, we selected 12 bird markets which were visited in the 2016–2017 survey and were still operating with un-negligible trade volume of birds for this survey, representing different geographical features across China. Four markets (Qingdao, Weifang, Jinan, Gaomi) in Shandong Province were surveyed, two markets (Pudong, Minhang) in Shanghai, two markets (Luoyang, Zhengzhou) in Henan Province, and one market each in Taiyuan of Shanxi Province, Chengdu of Sichuan Province, Liuzhou of Guangxi Province and Ningbo of Zhejiang Province (Fig. 1). Each of these bird markets was visited once in each season (Spring: March–May; Summer: June–August; Autumn: September–November; Winter: December–February), resulting in a total of 48 visits.

Each market was surveyed by the same person (s) for all four visits. Although all surveyors had previous experience in bird market surveys and skills in bird species identification, we conducted a 2-hour online training seminar for the surveyors before the survey in order to ensure the consistency, accuracy and efficacy of data collection and reporting. The training seminar covered such topics as brief introduction of commonly observed birds from the 2016–1027 survey, chat techniques with the sellers, safety, ethics and the recording and submission of data with pre-set forms and procedures. Species were identified by the experienced and skilled surveyors, if needed, with aid of a combination of the Field Guides to the Birds in China (MacKinnon and Phillips, 2000), photographs taken during the surveys and a mobile APP Dongniao, and the identification was verified by the fourth author who was an expert in bird species identification. And also, a WeChat group was set up for the surveyors to plan for the survey and to exchange information and experience in species identification.

During the surveys, the surveyor visited each selected bird market to record birds by counting openly displayed individuals for sale at individual stalls in the market, using the widely practiced direct counting method (DCM), and submitted their findings through survey forms (Bušina et al., 2021; Irham et al., 2019). The data collected included species identification, number of individuals, photos of the birds, and their protection status. The scientific nomenclature used in this study followed the taxonomy of the Checklist on the Classification and Distribution of the Birds of China (3rd ed.) (Zheng, 2017) which accounts for more recent taxonomic changes from the Field Guide.

Where possible, the surveyors, with their experience and knowledge in birds and bird trade, judged the sources of birds and categorised them into two groups: captive-bred ones and wild-caught ones. There were a few cases in which the sources of bird species were difficult to determine by the surveyors, the fourth author helped the determination and verified all the judgements of sources with aid of the WeChat group.

Because the bird trade in these markets was open, there was no need to rely on undercover techniques to obtain the above-mentioned information. However, it was still considered by the sellers as being annoying to ask repeatedly for price of the birds while no real purchase was made,

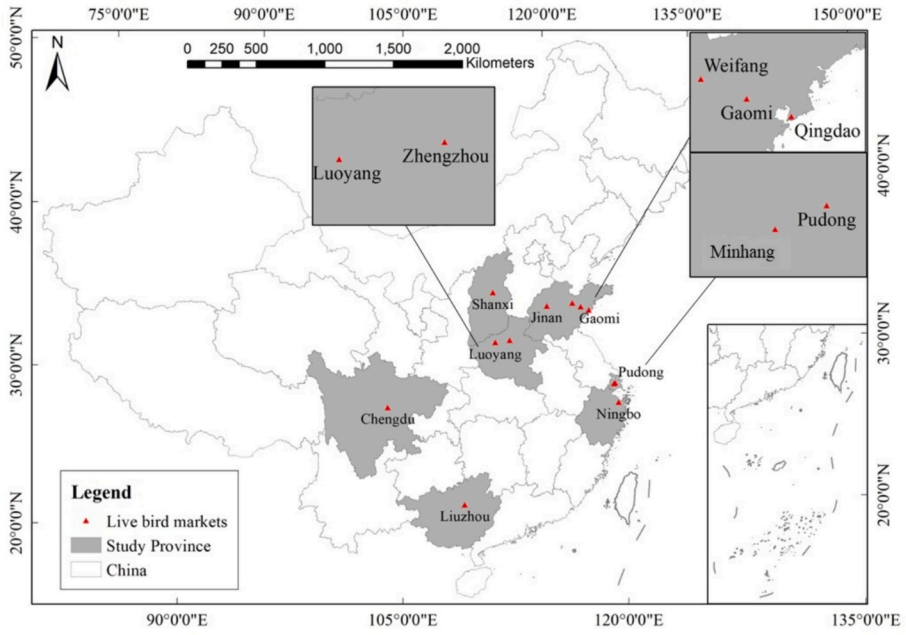

Fig. 1. Spatial distribution of 12 bird markets surveyed in this study.

so no information of asking price was collected. Despite of this, it would be better to collect the price information that could reflect many aspects of the bird markets.

For each species encountered, the surveyor recorded if it was: i) listed as the State Key Protected Wild Animals of China (Class I or Class II, NFGA, 2021a); ii) listed in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and if so, which appendix; and/or iii) listed in the IUCN Red List of threatened species and which threat category (Near Threatened and above).

Because all surveys in the bird markets were completed by local surveyors on one day (usually in the morning) and many sellers were observed to sell out their stocks at their stalls in the morning, it was reasonable for us to assume that the birds did not move between stalls in a single market, and that all birds were sold within one season with no birds returning to the market for resale (c.f. (Nijman et al., 2018; Regueira and Bernard, 2012)). And also, only one market was survey in a single city except in Shanghai where the two markets (Pudong and Minhang Markets) were far away from each other. It was almost impossible to move birds between different markets within a single day. Thus, we anticipated that the birds observed in the various bird markets were different individuals.

We described the number of individual birds and species in each market across each season and compared the seasonal variation between markets using standard deviations and coefficient of variation (CV). We examined the relationship between the percentage of wild birds in each market and the volume of birds observed in the market using the Pearson correlation coefficient.

3. Results

3.1. Overall situation of the bird markets

During the surveys, 150 bird species were recorded, including 119 wild species and 31 captive-bred species. A total of 46,202 individual birds were recorded, including 5863 wild birds (13%) and 40,339 captive-bred ones (87%), indicating that the captive-bred birds accounted for the majority of the birds recorded. The number of individual birds of eight captive-bred species exceeded 1000 each, and even over ten thousand individuals of the captive-bred budgerigar (*Melopsittacus undulatus*) were recorded (Table 1). In contrast, among the wild bird species observed in the markets, only the number of

Table 1
Top 20 captive-bred bird species and their quantity recorded in the survey.

Order	Family	Species	Scientific name	Quantity
Psittaciformes	Psittacidae	Budgerigar	*Melopsittacus undulatus*	18,532
Psittaciformes	Psittacidae	Fischer's Lovebird	*Agapornis fischeri*	3985
Passeriformes	Estrildidae	Zebra Finch	*Taeniopygia guttata*	3615
Psittaciformes	Cacatuidae	Cockatiel	*Nymphicus hollandicus*	3203
Passeriformes	Estrildidae	Java Sparrow	*Padda oryzivora*	2782
Psittaciformes	Psittacidae	Rosy-faced Lovebird	*Agapornis roseicollis*	2141
Passeriformes	Fringillidae	Atlantic Canary	*Serinus canaria*	1541
Collumbiformes	Columbidae	Rock Dove	*Columba livia*	1079
Passeriformes	Estrildidae	White-rumped Munia	*Lonchura striata*	657
Psittaciformes	Psittacidae	Grey-headed Lovebird	*Agapornis canus*	642
Psittaciformes	Psittacidae	Yellow-collared Lovebird	*Agapornis personatus*	470
Galliformes	Phasianidae	Chicken	*Gallus gallus domesticus*	453
Galliformes	Phasianidae	Japanese Quail	*Coturnix japonica*	383
Passeriformes	Estrildidae	Gouldian Finch	*Erythrura gouldiae*	296
Galliformes	Phasianidae	King Quail	*Synoicus chinensis*	229
Psittaciformes	Psittacidae	Red-headed Lovebird	*Agapornis pullarius*	121
Psittaciformes	Psittacidae	Monk Parakeet	*Myiopsitta monachus*	56
Psittaciformes	Psittacidae	Green-cheeked Parakeet	*Pyrrhura molinae*	40
Collumbiformes	Columbidae	Diamond Dove	*Geopelia cuneata*	38
Collumbiformes	Columbidae	Eurasian Collared Dove (Albino variety)	*Streptopelia decaocto*	23

individual Japanese White-eyes (*Zosterops japonicus*) exceeded 1000 (Table 2).

The survey recorded 16 captive-bred parrot species from Psittaciformes, accounting for only 11% of the total species, but the number of individual parrots was 29,206, accounting for 63% of the total individual birds (and 72% of the captive-bred individuals). Out of the 119 wild species recorded, 111 belonged to the order Passeriformes (93%) and the individuals (5842) from these 111 wild Passeriformes species accounted for almost all the wild birds in the markets (99.6%) and 12% of the total observed birds.

Among the 150 bird species recorded, 31 species were listed as the State Key Protected Wild Animals and/or in the CITES Appendixes and/or in the IUCN Red List, which accounted for 21% of all the species recorded, including 13 captive-bred species and 18 wild species. The number of individual birds of these 13 captive-bred species was 8491 (18% of the total number of captive-bred birds) and that of these 18 wild birds was 1473 (25% of the total number of wild birds) (Fig. 2).

3.2. Fluctuation in bird quantity with seasons and markets

The number of individual captive-bred birds recorded in six markets (Chengdu, Liuzhou, Qingdao, Ningbo, Zhengzhou, Minhang) exceeded 2000 each (Fig. 3). The Chengdu market recorded the highest volume of captive-bred individual birds, showing remarkably pronounced seasonal variation (Total = 7087; SD = 1563.92; CV = 0.883) with significantly higher number in spring and autumn than in summer and winter. The number of captive-bred individual birds recorded in the Luoyang city market showed similarly pronounced seasonal variation (Total = 1816; SD = 360.19; CV = 0.793).

Jinan Market recorded the largest number of individual wild birds (Total = 1034; SD = 135.56; CV = 0.524), and Gaomi Market (Total = 698; SD = 165.30; CV = 0.947) and Taiyuan Market (Total = 688; SD = 127.94; CV = 0.744) also had large volume of wild birds (Fig. 4). These three markets exhibited pronounced seasonal variations in the number of wild birds across seasons. Excluding Taiyuan Market that recorded very low number of captive-bred birds and Qingdao Market that recorded very low number of wild birds, the seasonal variation in the number of wild birds in the market ($\overline{CV}$ = 0.737) was more pronounced than that in the number of captive-bred birds ($\overline{CV}$ = 0.446).

There was a significant correlation between the market size (i.e., the total number of individual birds) and the percentage of wild birds (r = −0.636, $P < 0.05$), indicating that larger markets tended to have a smaller proportion of wild birds (Fig. 5).

Table 2
Top 20 wild bird species and their quantity recoded in the survey.

Order	Family	Species	Scientific name	Quantity
Passeriformes	Zosteropidae	Japanese White-eye	*Zosterops japonicus*	1456
Passeriformes	Zosteropidae	Chestnut-flanked White-eye	*Zosterops erythropleurus*	668
Passeriformes	Leiotrichidae	Chinese Hwamei	*Garrulax canorus*	310
Passeriformes	Emberizidae	Yellow-throated Bunting	*Emberiza elegans*	278
Passeriformes	Fringillidae	Eurasian Siskin	*Spinus spinus*	247
Passeriformes	Fringillidae	Grey-capped Greenfinch	*Chloris sinica*	217
Passeriformes	Paridae	Yellow-bellied Tit	*Pardaliparus venustulus*	164
Passeriformes	Sturnidae	Crested Myna	*Acridotheres cristatellus*	163
Passeriformes	Paridae	Cinereous Tit	*Parus cinereus*	157
Passeriformes	Muscicapidae	Siberian Rubythroat	*Luscinia calliope*	152
Passeriformes	Paridae	Coal Tit	*Periparus ater*	149
Passeriformes	Paridae	Marsh Tit	*Poecile palustris*	125
Passeriformes	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	111
Passeriformes	Paradoxornithidae	Vinous-throated Parrotbill	*Sinosuthora webbiana*	103
Passeriformes	Alaudidae	Eurasian Skylark	*Alauda arvensis*	102
Passeriformes	Fringillidae	Chinese Grosbeak	*Eophona migratoria*	95
Passeriformes	Fringillidae	Brambling	*Fringilla montifringilla*	93
Passeriformes	Timaliidae	Red-billed Leiothrix	*Leiothrix lutea*	87
Passeriformes	Aegithalidae	Black-throated Bushtit	*Aegithalos concinnus*	74
Passeriformes	Turdidae	Bluethroat	*Luscinia svecicus*	68

3.3. Seasonal variation in the number of bird species

Qingdao market recorded an average of 17 captive-bred species across the seasons, while Taiyuan market ranked the last with only one captive-bred species recorded in the autumn (Fig. 6). The remaining markets recorded roughly a similar number of captive-bred bird species around 10. The markets in Pudong (AVG = 12.25; SD = 5.12; CV = 0.418), Weifang (AVG = 7.75; SD = 3.40; CV = 0.439), Jinan (AVG = 11.25; SD = 3.86; CV = 0.343), and Liuzhou (AVG = 10.25; SD = 3.86; CV = 0.377) exhibited relatively marked seasonal fluctuations, but the other markets maintained relatively stable in captive-bred species diversity (excluding Taiyuan market).

Jinan Market had the highest number of wild species with an average of 31 species across the seasons, while other markets had an average number of 20 or even fewer wild species (Fig. 7). Four markets, namely Pudong, Liuzhou, Ningbo and Qingdao, had an average number of wild bird species below 10. The number of wild bird species fluctuated with seasons. For the same markets, more wild bird species were recorded in the spring and autumn than in the summer and winter seasons. Zhengzhou Market (AVG = 14.75; SD = 6.45; CV = 0.437), Luoyang Market (AVG = 14.5; SD = 7.32; CV = 0.505), Weifang Market (AVG = 14.5; SD = 7.32; CV = 0.505), and Pudong Market (AVG = 9.75; SD = 6.13; CV = 0.629) showed the most significant seasonal fluctuations in the number of wild species.

3.4. Comparison with the 2016–2017 survey

To compare with the 2016–2017 survey (KVBOI, 2018), we extracted the records of the same 12 bird markets as in this study and emphasized our comparison on wild birds.

The 2016–2017 survey of the 12 markets counted a total of 47,012 individual birds, among which 22,895 were wild birds belonging to 200 wild species. On the one hand, the current survey counted a total of 46,202 individual birds among which 5863 were wild ones of 119 wild species, indicating that the number of wild bird species and wild individual birds decreased by 41% and 74%, respectively, between the two surveys. On the other hand, the number of captive-bred individual birds increased from 24,117 in the 2016–2017 survey to 40,339 in the current survey, although the total number of birds was similar for the two surveys (47,012 vs. 46,202).

The individual wild birds (5863) accounted for 13% of the total birds (46,202) in this study, while the proportion of wild birds was 49% in the 2016–2017 survey (47,012). The proportion of captive-bred birds (mainly of several parrot species) increased from 51% in the 2016–2017

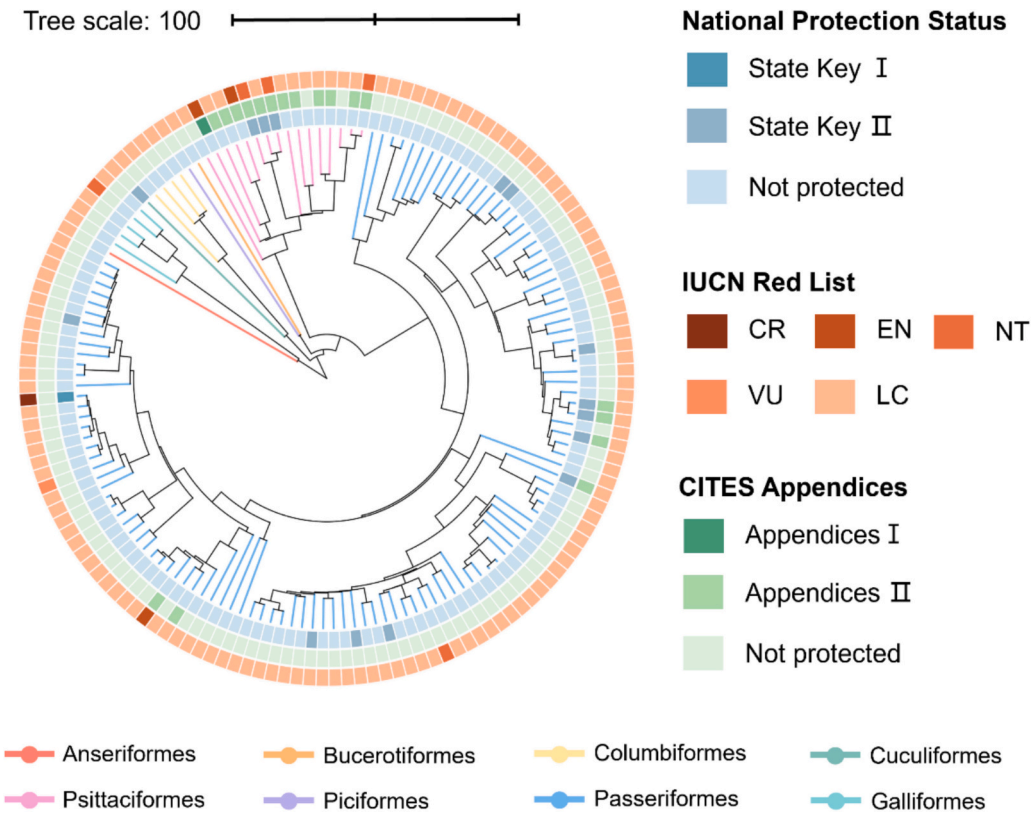

Fig. 2. A phylogenetic tree of the bird species recorded in the national bird market survey. Phylogenetic branches are colored to represent birds of different Orders. The outermost circle represents the IUCN conservation status for each species, the middle circle indicates the CITES appendix classification, and the innermost circle reflects the national protection status of each species. Branch lengths (tree scale) represent evolutionary time in 100× millions of years. (Jetz et al., 2012; Letunic and Bork, 2024). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

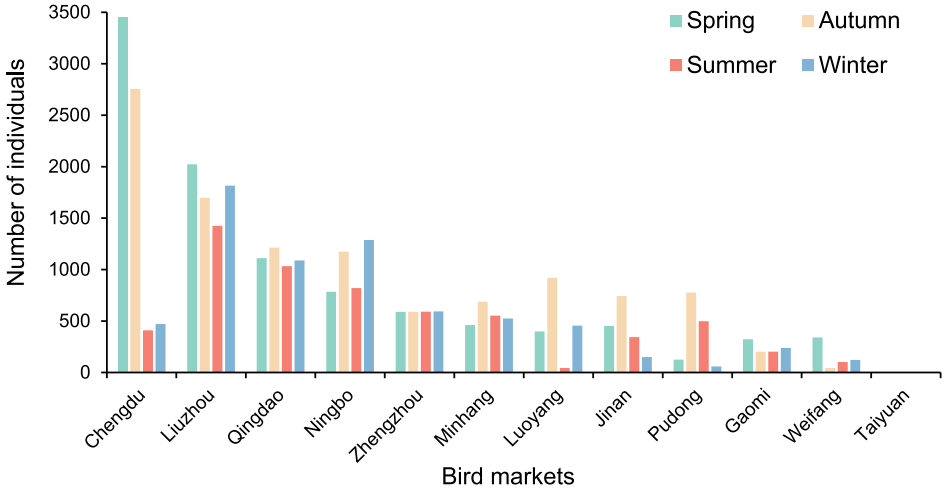

Fig. 3. Variation in the number of captive-bred birds recorded in each market in each season.

survey (24,117) to 87% in this study (40,339).

Although some species listed as the State Key Protected Wild Animals (2021) were observed in this study, e.g., Chinese hwamei (*Garrulax canorus*), Chestnut-flanked white-eye (*Zosterops erythropleurus*), Red-billed leiothrix (*Leiothrix lutea*), Siberian rubythroat (*Luscinia calliope*), Bluethroat (*Luscinia svecica*) and Mongolian lark (*Melanocorypha mongolica*), the number of these birds in the markets decreased substantially compared to the 2016–2017 survey when they were not listed as state key protected wild birds. The count of these six state key protected species decreased from 14,296 to 1332. As two of the most famous and popular traditional caged-songbirds in China, the number of Chinese hwamei and Mongolian lark decreased from 10,990 and 2251 individuals in the 2016–2017 survey to 310 and 44 individuals in this survey, respectively.

4. Discussion

Our study provides crucial insights into the shifting dynamics of China's live bird markets following recent regulatory changes and the COVID-19 pandemic. We found a drastic decline in the trade of wild-

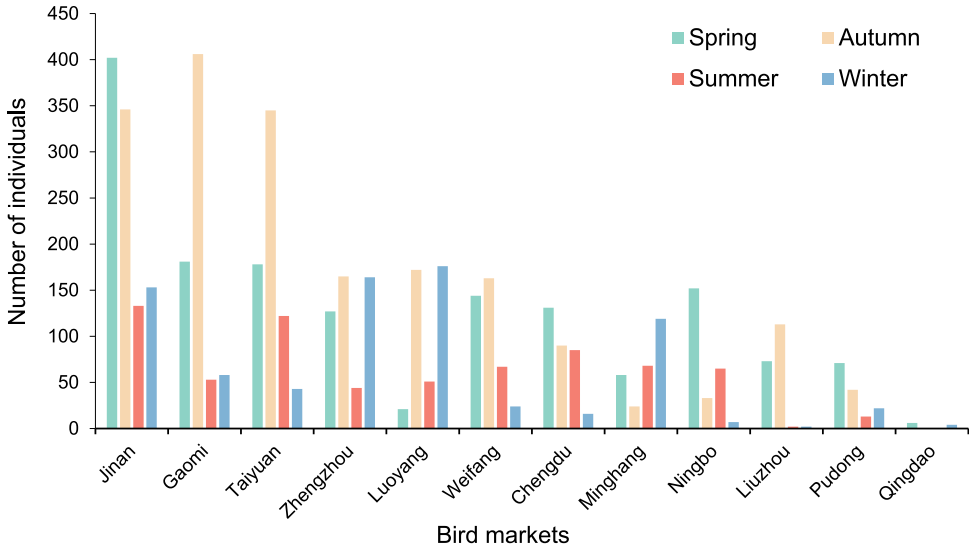

Fig. 4. Variation in the number of wild birds recorded in each market in each season.

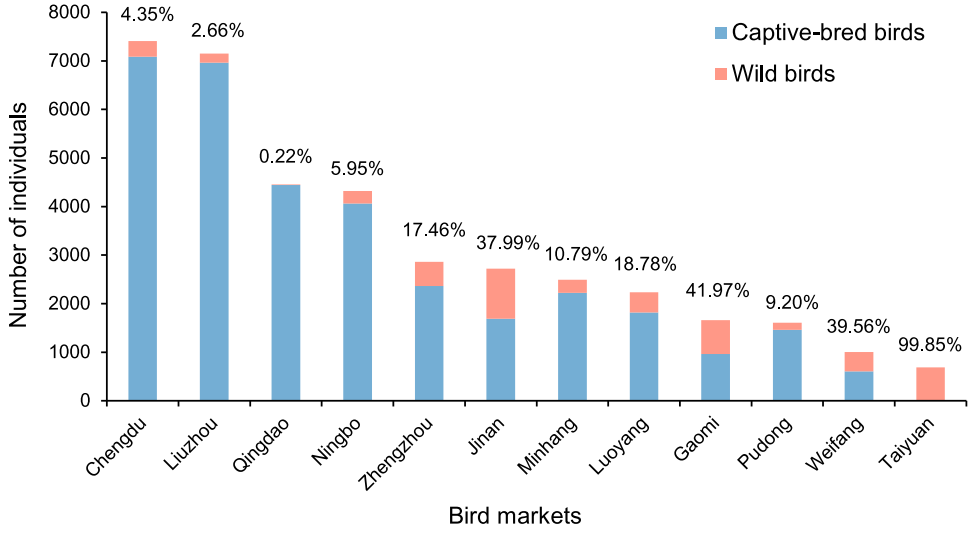

Fig. 5. The number of birds recorded and the percentage of wild birds in each market.

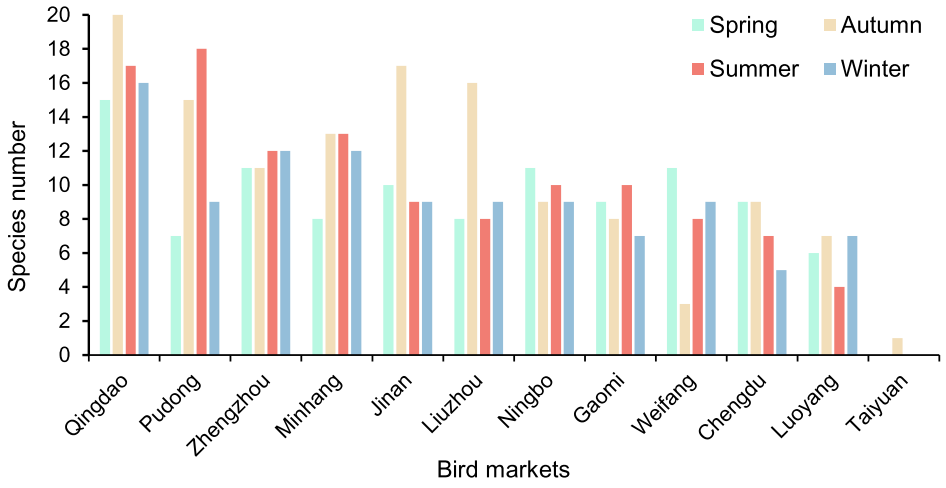

Fig. 6. The number of captive-bred bird species recorded in each market in each season.

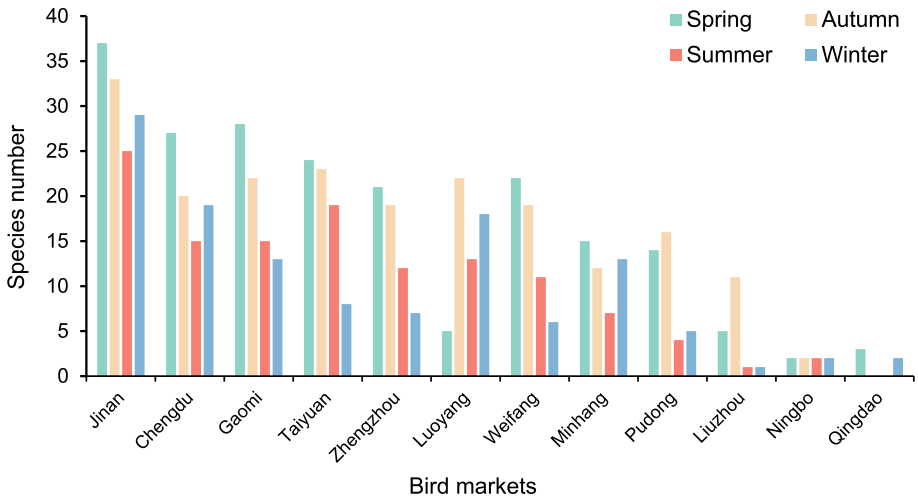

Fig. 7. The number of wild bird species recorded in each market in each season.

caught birds, with the number of wild bird species and wild individual birds decreasing by 40% and 75%, respectively. At the same time, the trade of captive-bred birds has expanded significantly, with their proportion rising from 51% in 2016–2017 to 87% in this study, primarily driven by the increase in parrot species. Additionally, we observed clear seasonal fluctuations, with higher trade volumes during spring and autumn, and a negative correlation between market size and the proportion of wild birds, indicating that larger markets might be better regulated. Understanding these trends and the drivers behind them is critical for developing more effective conservation strategies, ensuring that regulatory measures are effectively reducing pressure on wild bird populations caused by bird trades.

4.1. Evolution of bird market sizes between two surveys

The sizes of the 12 surveyed markets were very similar in the two surveys, possibly due to the features of the markets we selected for this survey. On the one hand, the 12 bird markets were typical ones with large volume of birds for sale in the 2016–2017 survey and were still operating with notable trade volume. The number of individual birds recorded in the 12 markets accounted for about 20% of the total among over 200 markets in the 2016–2017 survey (KVBOI, 2018). On the other hand, many traditional bird markets visited in the 2016–2017 survey were shut down permanently or temporarily and the remaining markets had only negligible trade volume due to the pandemic and the enhanced enforcements during our surveys (e.g. NPC, 2020b), as revealed by our screening survey. Thus, the size of the 12 selected markets could be considered as a representative of the overall size of physical bird markets across China during our survey, and the overall bird market size was then getting much smaller (ca. 20%) than in the 2016–2017 survey.

Such factors as the pandemic control measures, adjustment of wildlife protection policies and regulations, strengthened law enforcement in China appear to have had a significant impact on the scale of physical bird markets (You, 2020; Liang et al., 2024). On January 16, 2020, shortly after the outbreak of COVID-19 pandemic, Chinese government agencies issued an Announcement on the Prohibition of Wildlife Trade, requesting to strictly prohibit trade of wild animals at such places as agricultural or wildlife trade markets, e-commerce platforms (NFGA, 2020). On February 24, 2020, the Standing Committee of the National People's Congress, the highest legislative body of China, adopted a more powerful Decision on Comprehensively Prohibiting Illegal Wildlife Trade, Abolishing the Bad Habits of Indiscriminate Eating of Wild Animals, and effectively Protecting the Health and Safety of the People (NPC, 2020a). The enforcement of these new policies and regulations, together with other pandemic prevention measures, had immediate and influential impact in re-shaping the wildlife (bird) markets in China as suggested by a report (NPC, 2020b), which revealed that over 12 thousand wildlife-trade-related markets/places/business premises were shut down between February and August of 2020.

In addition, the rapidly developing online E-commerce platform, social media, chat groups, and other platforms may have gradually increased their share in the bird trade, which may have further accelerated the shrinkage of the physical bird market (Zhang et al., 2021). During the survey, some bird sellers mentioned that social media platforms were more accessible for the public, and more importantly, could effectively avoid being regulated and enforced. There have been thriving e-commerce platforms for wildlife trade (Yin et al., 2020; Ye et al., 2020; Wang and Chen, 2019). With the growing diversity of various platforms involving wildlife trade and the continuous advancement of smuggling techniques, the survey of physical markets alone often has limitations to reflect the real situation and volume of wildlife trade. The shrinkage of the physical bird markets as shown in this study does not necessarily imply that the bird trade volume (either legal or illegal) has declined accordingly. More comprehensive and long-term investigations and surveys of various wildlife markets and platforms are thus needed to obtain a whole picture of bird trades in China.

4.2. Changes in bird species composition between the two surveys

The bird composition in the market has been changed in terms of the substantial reduction in wild birds and increasing dominance of captive-bred birds, particularly parrots. Such change may have been resulted from several factors or a combination of them. The policy changes and strengthened wildlife enforcement after the COVID-19 outbreak seem to have immediate impact on the bird composition of the bird market (Hu et al., 2022; Zhu et al., 2023). The COVID-19 pandemic may have also contributed to such a shift by increasing public awareness of zoonotic disease risks associated with wild animals and generating fear around the consumption and trade of wild animals (Enns et al., 2023). It is also possible that this change may reflect a true reduction in public demand for wild birds and a shift to alternative captive-bred birds (Bušina et al., 2021; Harris et al., 2015; Irham et al., 2019). Despite of these, the increasing dominance of captive-bred parrots in the market suggests that captive breeding is playing a significant role in reshaping the bird markets, which may have broad implication for using some captive-bred popular parrots as substitute for wild birds as pets.

Studies have predicted that the pet bird market in China will grow steadily with increase in per capita disposable income and the aged tendency of human population (Chinese Pet Industry White Paper, 2019; Ni et al., 2022). Thus, policymakers face the challenge of balancing the

protection of wild bird populations and meeting the public demand for pet birds. One potential solution is to reduce demand for wild-sourced birds by promoting the use of captive-bred birds from sustainable breeding practices (Nelson and Shepherd, 2023). Captive breeding has been proposed as a strategy to alleviate pressure on wild populations, but its effectiveness depends on strict regulatory oversight, species suitability, market acceptance (Tensen, 2016; Jepson and Ladle, 2009). While these challenges mean that captive breeding as a conservation tool is not guaranteed to succeed, a well-developed and regulated captive breeding industry may provide favorable conditions for reducing reliance on wild-caught birds (Biggs et al., 2013; Phelps et al., 2016).

Several non-native parrots such as budgerigars and Fischer's lovebirds dominated the captive-bred bird trade in the market, reflecting an ample supply of them. For instance, in Shangqiu City, the annual legal trade volume of these species can reach up to 10 million individuals (source: https://baijiahao.baidu.com/s?id=1714360650256457718&wfr=spider&for=pc). The maturity of captive-breeding techniques has made these species particularly easy to breed, allowing breeders to produce large quantities at low costs without relying on wild individuals for stock. Keeping and trading such popular captive-bred species could provide an option to both reduce pressure on wild bird populations and meet public demand (Cooney and Jepson, 2006; Jepson and Ladle, 2005), if their demand for wild-caught birds could be reduced or even shifted to these popular captive-bred species.

Reducing the public demand for wild birds and shift of their preference for a particular species (or group) of wild birds (like the Chinese hwamei) to captive-bred birds is difficult, but our recent research (unpublished) may offer a glimmer of hope. The parallel survey on bird-keeping attitudes in China found that 60% of respondents had kept or were keeping birds for companionship, with parrots (62%) and Chinese hwamei (36%) being the most popular species, and 56% opposed the keeping of wild-sourced birds (manuscript under review). While self-reported attitudes are susceptible to social desirability bias (Chiok et al., 2022), these findings suggest a potential shift of the public demand from wild-sourced birds to captive-bred alternatives. Similar to the situation in many other countries or regions (e.g., Japan (Vall-Llosera and Su, 2019)), the parrot trade dominates both legal and illegal bird trade markets in China in recent years (Wang et al., 2021).

Although captive breeding has, in some cases, been exploited to launder wild-caught birds (animals), the breeding of non-conservation concern exotic species such as lovebirds and budgerigars may present a promising approach (Jepson and Ladle, 2009; Marshall et al., 2020). Given the large-scale industry for captive-bred parrots and their increasing market shares, further research is needed to comprehensively assess whether they can serve as a sustainable alternative to wild-sourced pet birds without compromising conservation efforts.

4.3. Trade of the state key protected birds

It is worthwhile to note that 31 species of conservation concerns were observed for sale in the markets, although their number and proportion were much low. Among them, 16 species are native to China and have been listed as either Class I (Yellow-breasted bunting) or Class II (e.g. Chinese hwamei *Garrulax canorus*) State Key Protected Wild Animals with more strict legal protection (newly revised in 2021), compared to 34 state key protected species recorded in the 2016–2017 survey. Some of them (e.g. Chinese hwamei, Chestnut-flanked white-eye *Zosterops erythropleurus*, Mongolian lark *Melanocorypha mongolica*, Red-billed leiothrix *Leiothrix lutea*) have been traditional caged-songbirds and very popular in bird markets in China in the past, but they were not under legal protection before 2021. The number of Chinese Hwamei and Mongolian lark recorded for sale in the markets decreased from 10,990 and 2251 individuals in the 2016–2017 survey to 311 and 44 individuals in this study, respectively.

The list of the State Key Protected Wild Animals, revised and updated in 2021 for the first time since its first release in 1989, increases substantially coverage of birds from 244 species to 394 species. Listing and addition of such native songbirds as Chinese hwamei, Chestnut-flanked white-eye, Mongolian lark, and Red-billed leiothrix to the list in 2021 means that it is illegal to trade and to keep such birds without appropriate licences and thus offers a significantly greater level of protection for them (e.g. Liang et al., 2024; Xiao et al., 2024). Anyone who violates these regulations by capturing or keeping Class II or I state key protected wild birds like Chinese Hwamei without appropriate permits can be subject to severe punishment including fixed-term imprisonment ranging from six months to several years and additional large fines (Dai, 2022). The changes in the list and other relevant policies have been enforced, resulting in many cases of imprisonment for those who caught and traded such songbirds as Chinese hwamei (e.g. https://m.thepaper.cn/baijiahao_29327161). So, the listing and addition of these songbirds has been considered having deterrent effect on their trade in the markets. The surveyors' casual chat with the vendors in the market confirmed this, but the presence of such illegal bird trade at the markets (and possibly at other platforms) still warrants our concern over their protection, and in turn close monitoring and strict enforcement.

In addition, there may be other reasons for the shrinkage of the trade volume of these key protected wild birds. First, the trade volume of these key protected species was likely to be underestimated due to the existence and development of underground markets and other trade platforms (Regueira and Bernard, 2012; Liang et al., 2024). Second, it may be more difficult to find and capture these birds in the wild compared to the previous survey. There have been no nation-wide investigation into or report of the status of wild populations of these birds, but some localised studies can provide information on their wild populations. For example, an interview with a local Miao community in Guizhou of China indicated that most interviewees (bird-keepers) believed that the wild Hwamei population was stable there (Dai, 2022).

Because these traditional caged and protected songbirds such as Chinese hwamei and Chestnut-flanked white-eye are popular with deep social and cultural roots and in high demand mainly for their beautiful sound and plumage (Dai, 2022), legal prohibition of their trade may lead to a massive gap in the market, which may further motivate illegal hunting for them to meet the market demand since they could not be artificially bred and sustainably produced easily. Therefore, studies are needed to understand drivers of purchasing decisions, and it is worth to explore the approaches to reduce the public's demand for such wildlife as Chinese hwamei that are under legal protection but difficult to breed in captivity (Echeverri et al., 2020). The promotion of the captive-breeding of popular but usually wild-caught species like Chinese hwamei and Chestnut-flanked white-eyes should be considered and treated cautiously (Marshall et al., 2020).

4.4. Additional bird market characteristics and their conservation implications

Our study finds significant seasonal fluctuations in the number of birds and species recorded in the markets. Many captive-bred bird species could be supplied consistently throughout the year to meet the market demands, while the species and number of wild birds fluctuated more markedly, with the number being generally higher in spring and autumn than in other seasons. The months from March to May and from September to November coincide with the bird spring and autumn migration seasons and mark the peak of the wild bird trade. This indicates, to a large extent, that the seasonal fluctuation of bird markets is a common feature of the nationwide markets involving wild bird trade, rather than a typical feature of the individual bird markets (Fiennes et al., 2021; Bi and He, 2005; Li et al., 2019). Therefore, enforcement actions against illegal bird (wildlife) trade could be planned and tuned well for bird markets with significant seasonal fluctuations.

The proportion of wild birds recorded in each market negatively correlated with the market size. Larger markets tend to have a relatively mature management style including enhanced supervision and

enforcement by relevant government agencies, and are thus able to attract more stable suppliers (captive breeders) to provide birds to the market. For small-scale bird markets, they are mainly composed of movable stalls that are usually run by local older residents. Their awareness of wildlife protection is usually much lower than young people, making it almost impossible for them to differentiate whether a captured bird is protected or not. It is also usually difficult to manage and penalize them due to the small quantity of birds sold and the random nature of the sale. This finding imply that bird market managers could invest more in creating and standardizing larger markets to create a more conducive trading environment for fixed stall-holders. This will not only ease the pressure of law enforcement, but also squeeze the market share of the wild birds, thus promoting the sustainable development of regulated captive-bred bird markets in China.

However, it is worth noting that changes in market management systems may inadvertently harm people who rely on these markets for their livelihoods, particularly the older ones (Enns et al., 2023). The surveyors' observation over the sellers in the markets shows that most sellers were not professional and full-time bird dealers, and they did not rely on bird trade for their livelihoods. This was particularly true for the older sellers in the markets who sold birds that were usually captured from their own backyards and orchards (KVBOI, 2018; communication with the surveyors).

4.5. Limitation and considerations for further studies

The bird markets/trades are complex and influenced by many factors. We acknowledge that the lack of price data in this study has restricted our ability to assess the economic drivers of the bird markets/trades. Bird prices are shaped by species availability, conservation status, body size, song attractiveness, and color preferences (Su et al., 2015), and are an important determinant of consumer choice and demand elasticity, influencing whether buyers opt for captive-bred or wild-caught birds. Without access to price data, it remains unclear whether the observed shift towards captive-bred birds (as in this study) is a true change in consumer preference or simply a response to cost differences. Economic research has demonstrated that price fluctuations can reflect and influence trade patterns (Harris et al., 2015). Therefore, future studies should integrate pricing models, demand elasticity assessments, and cost-benefit analyses to better understand the interplay between economic forces and conservation policies (Jepson and Ladle, 2011).

The market shift observed in this study may primarily reflect policy-driven supply constraints rather than evolving buyer preferences. Previous research highlights that cultural traditions, aesthetic preferences, spiritual enrichment, and socio-economic factors play a significant role in shaping bird trade decisions (Burivalova et al., 2017; Su et al., 2015; Santangeli et al., 2023; Belaire et al., 2015). Additionally, while raising public awareness is often proposed as a conservation strategy, behavioral change requires more than education alone (Veríssimo et al., 2024). Consumer behavior is shaped by economic incentives, regulatory enforcement, and social norms. Future studies could incorporate consumer preference surveys, experimental market interventions, and long-term behavioral monitoring to assess whether captive-bred birds can effectively replace wild-caught ones in the pet trade.

In summary, the trade volume (in terms of the number of individual birds and species) of the bird markets has reduced, and the bird composition of the markets has changed with substantial reduction in wild-sourced birds and increase of captive-bred birds, dominated by several parrots, between the two surveys as a result of the newly introduced wildlife regulations and their enforcement, the COVID-19 pandemic and other possible factors. While bird market surveys could support the conservation of wild bird populations and the entire ecosystem, but only market survey is not enough and cannot reflect the whole picture of bird trade. It is important to monitor and survey other forms of markets (e.g. online platforms, social media, underground markets, etc.) for bird (wildlife) trade, and to dig into the various factors influencing the pattern and scale of the markets to obtain a whole picture of bird trade in China. Although it is difficult to identify the exact reasons for the bird market changes, the changes may have implications for developing and managing a well-regulated captive breeding program of several popular parrot species without conservation concerns as a substitute for wild birds to meet the public increasing demand for birds and protect wild bird populations at the same time. Further studies are needed to better understand the interplay between economic forces and conservation policies and to explore whether captive-bred birds can effectively replace wild-caught ones in the pet trade.

CRediT authorship contribution statement

Jinming Zhang: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Jianbin Shi:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Rumei Zhang:** Writing – review & editing, Data curation. **Qian Wei:** Writing – review & editing, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Yuyanran Cao:** Writing – review & editing, Resources, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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