Trends in legal and illegal trade of wild birds: a global assessment based on expert knowledge

16 authors, including:

Joana Ribeiro
University of Porto
10 PUBLICATIONS **61** CITATIONS

SEE PROFILE

Luís Reino
CIBIO/InBIO Research Center in Biodiversity and Genetic Resources
92 PUBLICATIONS **1,314** CITATIONS

SEE PROFILE

Stefan Schindler
Umweltbundesamt, Austria
108 PUBLICATIONS **3,693** CITATIONS

SEE PROFILE

Diederik Strubbe
Center for Macroecology, Evolution and Climate
101 PUBLICATIONS **1,438** CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Bats on islands: ecology, behaviour and conservation biology View project

Livelihood options of deep-sea, shark fishing communities in Sri Lanka and India and implications for distant-water MPA management View project

ORIGINAL PAPER

Trends in legal and illegal trade of wild birds: a global assessment based on expert knowledge

Joana Ribeiro, et al. *[full author details at the end of the article]*

Abstract

Wildlife trade is a profitable economic activity. Birds are among the most heavily traded animals worldwide, with numerous species threatened by pet trade. Information on both legal and illegal aspects of trade and consumer demand is difficult to obtain across different countries, particularly given substantial socio-economic and cultural variation. Focusing on consumer demand in each country, we conducted a global survey among 105 international experts on bird conservation to identify expected trends, drivers and market characteristics of legal and illegal wild-caught pet bird trade. Our results suggest that future trends in legal bird trade will be mostly driven by socio-cultural motivations and intentional demand for wild-caught, rather than captive-bred birds. Bird popularity and rarity are the main factors expected to influence the choice of which bird species will be the most traded legally. Percentage of rural population was the main national-level socio-economic predictor for legal bird trade in the future. Demand for future illegal trade is expected to be driven by bird popularity and particular species identity. Experts consider illegal trade to be sustained mainly by consumers from higher socio-economic and educational backgrounds. Human population growth rate was the main national-level socio-economic predictor of illegal trade expected for the future. Legislation enforcement remains a critical issue in wildlife trade. Expanding trade networks and socio-economic changes continue to incorporate new regions into the wildlife trade. Investigating the multidimensional and synergistic determinants of wildlife trade will thus help address potential detrimental impacts bird trade might cause on biodiversity.

Keywords Biological invasions · CITES · Consumer behaviour · Expert elicitation · Global wildlife trade · Invasive species

Communicated by Adeline Loyau.

This article belongs to the Topical Collection: Biodiversity exploitation and use.

 Springer

Introduction

Wildlife trade is a profitable economic activity, with billions of living organisms or derived products being traded around the world annually (Karesh et al. 2005; Jenkins 2007; UNEP-Interpol 2016). However, unsustainable and/or illegal wildlife trade may pose major threats to global biodiversity, particularly in African, Asian, and South American countries (da Alves et al. 2013; Challender et al. 2015; UNEP 2018), where the livelihoods of local communities dependent upon those resources may also be affected (but see TRAFFIC 2008; Nijman 2010). In addition, wildlife trade is a common pathway for the introduction of invasive species (Carrete and Tella 2008; Essl et al. 2015; Cardador et al. 2019), which cause detrimental impacts on ecosystems, economic activities and human welfare (Simberloff et al. 2013).

Pet trade is a substantial component of wildlife trade (Bush et al. 2014; Chng et al. 2015; Auliya et al. 2016). Although detailed data on wild-caught traded animals are difficult to obtain, it is estimated that billions of wild animals are globally traded as pets every year (Karesh et al. 2007; Smith et al. 2012), and that 25% of the global exotic pet trade is illegal (Karesh et al. 2007). Birds are one of the most commonly traded taxonomic groups worldwide, with ca. 4000 of both wild-caught and captive-bred origin species sold and kept as pets (Birdlife International 2015). In fact, approximately a third (> 400) of all globally threatened bird species are thought to be affected by overexploitation for food or cage bird trade (BirdLife International 2008). During the 1990s, 2–5 million birds/year were traded worldwide (BirdLife International 2008), while in 2017 there were over 49 million birds kept as pets in European households (FEDIAF 2018). As numbers of captive animals soar, so does the risk of their accidental or deliberate release into the wild, and thus pet trade is a conservation challenge also as a source of invasive species (Hulme 2009; Abellán et al. 2016; Cardador et al. 2019). A better understanding of the socio-ecological characteristics of the trade of birds as pets is therefore paramount for the development of effective management tools, capable of simultaneously preventing the depletion of native populations and the establishment of new avian invaders.

Wildlife trade management commonly employs a range of tools aimed at regulating harvest and trade. However, differences in trade drivers, extent of natural resource use, governance, monitoring and enforcement among countries affect the effectiveness of management measures (Shepherd and Nijman 2008; Chan et al. 2015). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) entered in force in 1975 to prevent international trade in specimens of wild animals and plants from threatening their survival in the wild (Convention on International Trade in Endangered Species 2016, www.cites.org). While CITES has been considered crucial for ensuring the survival of some threatened species (e.g. Doukakis et al. 2012), its effectiveness relies on a Party's (i.e. a State or regional economic integration organization for which the Convention has entered into force) ability to implement and enforce it. However, this is often hindered by limited resources and enforcement capacity (which may promote corruption), particularly where there is a high local dependence on economic benefits associated with the international trade of wild species (Jepson and Ladle 2005; Regueira and Bernard 2012). Several other international, regional- and national-level measures, such as domestic bird trade regulations, have also been implemented to further reduce the negative consequences that might arise from trade (Challender and MacMillan 2014). In 2005, avian influenza outbreaks motivated the European Union to implement a ban (made permanent in 2007) on the importation

of wild-caught birds, regardless of their conservation status (Commission European Communities 2007). This ban provoked a rapid trade shift from wild-caught birds to captive-bred birds, allowing the maintenance of bird availability in markets (Cardador et al. 2019). However, there is some evidence that such bans might impair sustainable development, promote the trade of non-target taxonomic groups (Cardador et al. 2017), increase financial incentives for poaching or lead to the involvement of criminal organizations (Cooney and Jepson 2006; Challender and MacMillan 2014; Challender et al. 2019). Challender and MacMillan (2014) argue that interventions must go beyond regulation and build capacity within local communities to help manage wildlife, because when locals are engaged in the process, they are more likely to follow and enforce rules (Ostrom and Nagendra 2006). For example, the Argentinian government replaced a poorly regulated trade of blue-fronted amazon parrots (*Amazona aestiva*), that yielded minor revenues to local people, with a program that reduced unsustainable trade and produced revenues that financed protected areas and local landowners (Rabinovich 2012). Hence, while the conditions under which well-managed wildlife trade yields benefits for conservation and livelihoods are complex, evidence suggests it can be done (for more examples see Roe and Booker 2019).

While there are a number of different initiatives aimed at managing bird trade across the world, varying in their aims and scales (e.g. international and domestic trade), reliable information on both legal and illegal aspects of wildlife trade is difficult to obtain across different countries. Only CITES trade database aims to provide such information, but there are concerns over its accuracy, as it is highly dependent on a party's ability to enforce but also report. In addition, uncovering the complex characteristics of human demand for pet birds is essential for improving management and preventive measures (Jepson and Ladle 2005; Burivalova et al. 2017), particularly given socio-economic and cultural variation among countries (da Alves et al. 2010; Roldán-Clarà et al. 2017).

Aiming to better understand consumer demand for wild-caught birds as pets within a given country (i.e. demand for birds which might be domestically or internationally sourced, but are purchased within a specific country), we undertook a global survey to identify drivers, market characteristics and expected trends of legal and illegal pet bird trade. Thus, firstly, we identified consumer socio-demographic profiles, motivations and preferred bird characteristics at national level, assessed experts' perceptions of legislation effectiveness and explored key consequences and challenges of illegal pet bird trade. Secondly, we tested national-level socio-economic and environmental factors as potential predictors of bird trade, to characterize regions where increased legal and illegal trade could be expected. Finally, we explored the potential consequences of increased legal and illegal trade, and provide informed guidance for future legislations and tools addressing wild bird trade. For these purposes, we used expert elicitation and available information on socio-economic and environmental variables at the country level. Expert knowledge, defined as the information acquired through training, research, skills and personal experience on a certain subject not widely known (Burgman et al. 2011), has been increasingly used in conservation science (e.g. TRAFFIC 2008) to address complex problems whose investigation is urgent but often impaired by limited resources (Martin et al. 2012; Pullin et al. 2016; Pe'er et al. 2017). This approach is especially relevant for our study given that information on wildlife trade, particularly focused both on legal and illegal actions, is generally not available or is difficult to collect at the global scale (Rosen and Smith 2010; Robinson and Sinovas 2018).

Methods

Data collection

Survey approach

We used expert elicitation to gather insights into potential trends and drivers of consumer demand for wild birds as pets at national levels across the world. Bird trade experts were selected based on two criteria: (1) being an author of a peer-reviewed publication related to this research topic; and/or (2) being a representative of a non-governmental organization targeting bird conservation, research or trade with relevant knowledge about the topic.

A total of 98 academic experts were identified through a literature search of peer-reviewed publications related to this topic on ISI Web of Knowledge, Google Scholar, and Scopus, employing the search query: ("trade" OR "market") AND ("aves" OR "birds" OR "bird demand" OR "desired bird traits" OR "pet bird"). The last literature search was performed on the 12nd March 2018. The abstract of each retrieved paper was read in order to verify its relevance for the topic and the corresponding and/or first authors of each relevant paper were identified. Representatives of non-governmental organizations (NGOs) devoted to bird conservation were compiled from the Birdlife International network (a global partnership of bird conservation organisations—see list of partners at http://www.birdlife.org/worldwide/partnership/birdlife-partners). Contacts from TRAFFIC (a wildlife trade monitoring network, NGO) offices worldwide (available at http://www.traffic.org/contact/) were added to our list of potential participants due to their expertise on wildlife trade. This resulted in 147 NGO representatives invited in the initial stage of the survey campaign. To increase the number of respondents and country coverage, whilst avoiding potential sampling biases due to researchers' personal networks and perceptions about the issue (Newing 2010), we also employed snowball sampling, requesting all those directly contacted to recommend additional participants among colleagues, peers and other organizations that may have relevant knowledge and experience (Faugier and Sargeant 1997). This resulted in 111 additional contacts to be approached, 13 of which were academic experts, and the remaining 98 were NGO representatives. Overall, a total of 356 participants were invited.

Survey implementation

An online survey questionnaire (implemented in the Survey Gizmo web platform; www.surveygizmo.com) in English was used to collect information from participants. At the beginning of the questionnaire, each participant was asked to name their country of expertise (i.e. a single country they felt most familiar with regarding bird trade, research and/or conservation), so all the subsequent answers referred to this specific country. The questionnaire was divided into six sections (A to F) designed to obtain information on key aspects of the trade of pet birds (full questionnaire available in Supplementary Material A). Section A asked about the participants' professional background and familiarity with bird trade. Section B examined the participants' perception of the pet market characteristics, trends and implications (e.g. consumer characteristics and motivations, perceived changes in market trends and their drivers in the country of expertise). Section C focused on the perceived effectiveness of the national/international policies and regulations (e.g. CITES, EU ban, national-level bans on wildlife exports). Section D asked for suggestions to address

illegal bird trade. Section E requested basic socio-demographic information about the participant. Finally, participants were asked to suggest other experts whom we could invite for the survey (i.e. colleagues, peers or organizations), given their relevant knowledge and experience on the research topic. Experts suggested by questionnaire participants would only be invited to complete the survey if they had not already been contacted in previous elicitations.

The questionnaire was pretested from 2nd to 12th March 2018 using a pilot group composed of ten amateur ornithologists, researchers, and NGO workers (this group was excluded from the survey). Their responses helped determine average questionnaire completion time, redefine objectives, broaden the scope of the questions and improve the clarity of the questionnaire. A single link with the final version of our questionnaire was then sent to all pre-selected respondents. The survey was conducted from March 14th to May 2nd 2018 (7 weeks). During that period, two reminders were sent (April 4th and 18th). Consent for participation was obtained from each survey respondent and participants were provided with a description of the general aims of the project before the survey. This research was approved by the University of Exeter Ethics Committee (Ref. 2018/2102).

National-level socio-economic and environmental variables

Twelve socio-economic and environmental variables potentially associated with bird trade (Brenton-Rule et al. 2016) were compiled for all the participants' countries. Definition of each variable, rationale for inclusion and source of information are provided in Table 1.

Expert's perceived versus documented illegal trade fluxes

In order to identify the main global fluxes of illegal international wildlife bird trade as perceived by experts, we asked if they considered their country of expertise to be mainly an importer, exporter, both (importer and exporter), or none. If the answer was one of the first three alternatives, the expert was presented with an open-ended question about their perceived main regions of origin (if they considered their country of expertise mainly an importer), destination (if considered mainly an exporter), or both (if considered both exporter and importer) for illegally traded wild pet birds. To compare expert's perceptions to recorded fluxes of illegal bird trade, we also obtained data on confiscations/seizures of live wild birds performed under CITES retrieved for the period 2006–2016 for all countries from the CITES trade database (https://trade.cites.org/, accessed on 30 July 2018).

Data processing and analysis

Questionnaire responses were used for: (i) developing a score for ranking perceived trends in legal and illegal bird trade in the past 10 years (approximately since the EU ban), and expected for the next 5 years (a period respondents might perceive as reasonable for forecasting); (ii) modelling legal and illegal trade scores using ordinal regressions to explore trade characteristics, and socio-economic and environmental correlates (using compiled national-level variables; Table 1); (iii) comparing experts' perceptions of illegal international pet bird trade fluxes versus data on confiscations/seizures of live wild birds performed under CITES; and finally (iv) presenting the main challenges, consequences and solutions proposed by experts to control illegal bird trade. Each of these steps is explained in the following subsections and schematized in Fig. 1.

Table 1 Country-level socio-economic and environmental variables used as potential predictors of wild-caught bird pet trade, with respective definition, rationale and source of information

Variable	Definition	Rationale	Source
Socioeconomic variables			
Corruption perception index (CPI)	Perceived levels of corruption determined by expert assessments and opinion surveys, defining corruption as the misuse of public power for private benefit	Corruption facilitates wildlife trade at all levels, from petty briberies of low-field personnel to grand corruption involving governmental leaders (Haenlein and Smith 2017)	https://www.transparency.org
Rural population (%)	Percentage of country's population living in rural areas	In rural areas there is a high degree of dependence upon natural resources for income generation, health, food and security (Roe et al. 2002)	https://data.worldbank.org
Gross domestic product (GDP) *per capita* (GDPpc)	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. GDPpc is gross domestic product divided by midyear population. Data are in current U.S. dollars	Increased GDPpc causes expansion of industry, trade and investment, changing the demands, aspirations and purchasing power of the population, potentially affecting wildlife trade (TRAFFIC 2008)	https://data.worldbank.org
GINI index	Extent to which the distribution of wealth in the population deviates from a perfectly equal distribution	International traders benefit from poverty and inequality to allure to wildlife trading, trapping and poaching (Haken 2011)	https://data.worldbank.org
Tourism	International tourism receipts as percentage of total exports	Increased revenues from tourism, and wildlife-based tourism can make significant contributions to local livelihoods and national economic development (Department for Environment, Food & Rural Affairs and Department for International Development 2014)	https://data.worldbank.org
Unemployment	Percentage of the population who is unemployed	High unemployment rates associated to flourishing legal and illegal wildlife trades (Fleming et al. 2014)	https://data.worldbank.org

Table 1 (continued)

Variable	Definition	Rationale	Source
Population growth rate	Annual population growth rate for year t is the exponential rate of growth of midyear population from year $t-1$ to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship	Human population growth is a major cause of wildlife loss worldwide. Wildlife species satisfying a number of human needs, decline or disappear as human populations clear wildlife habitats for anthropogenic activities (Masanja 2014)	https://data.worldbank.org
Total natural resources rents	Percentage of GDP from oil, natural gas, coal, mineral, and forest rents	Increased dependence from exports of non-renewable natural resources is associated with poorer economic performance, lower human development and higher inequality and poverty, all correlates of wildlife trade (Williams and Le Billon 2017)	https://data.worldbank.org
Environmental variables			
Forest area	Percentage of country land covered by forest formations	Percentage of forest area may be a proxy for the amount of natural resources available. In biodiversity-rich developing countries, people depend on natural resources (Guyer et al. 1992; Roe et al. 2002)	https://data.worldbank.org
Protected area	Percentage of country land under protection	A key response to global biodiversity declines and the associated threatening processes, has been the establishment of protected areas (Barnes et al. 2016). Hence, the percentage of area under protection may indicate how vulnerable the country is to wildlife trade	https://data.worldbank.org
Number of bird species per km^2	Number of bird species per square kilometre	Proxy for the amount of bird species available. In biodiversity-rich developing countries, people depend on natural resources (Guyer et al. 1992; Roe et al. 2002)	https://ebird.org
Bird species threatened	Percentage of species categorized with a threatened status (i.e. critically endangered, endangered, vulnerable and near threatened) according to the IUCN Red List	Proxy for the amount of bird species that may be targeted	https://ebird.org
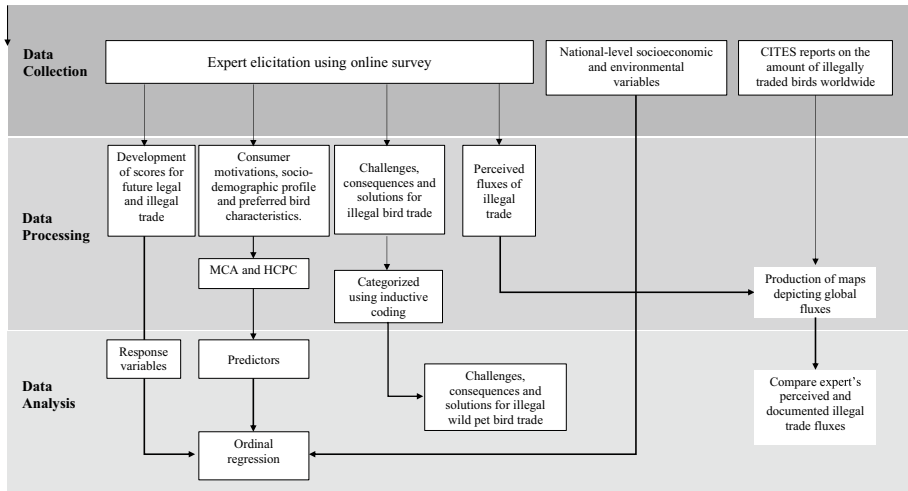
Fig. 1 Schematic representation of the study framework

Trade score development

Using experts' perceptions on multiple indicators (i.e., number of birds legally traded, number of bird species legally traded, price of birds legally traded, overall economic value of legal bird trade, number of birds illegally traded, number of bird species illegally traded, price of birds illegally traded, and overall economic value of illegal bird trade), scores describing trends for legal and illegal trade of both wild-caught and captive-bred pet birds (henceforth referred to as pet bird trade) in each country were developed. For each one of these indicators, survey participants were asked to report the perceived trend in their country of expertise during the previous 10 years and their expectation for the next 5 years. Available options for each indicator followed a Likert scale and were "decreased substantially", "decreased slightly", "no change", "increased slightly", "increased substantially" and "don't know". "Don't know" answers were excluded from the trade score scale and remaining options were attributed a numeric score from -2 ("decreased substantially") to 2 ("increased substantially") (Table B.1 in Supplementary Material B).

Scores attributed to each indicator were grouped into four overarching trade metrics, namely: past legal, past illegal, future legal and future illegal wild-caught bird trade. For each metric, the median overall score across indicators representing each expert's judgement was determined for each answer (median is the recommended measure of central tendency for Likert scale data; Jamieson 2004). This ranking ensured that a higher positive score (e.g. 2) corresponded to an expected substantial increase in wild bird trade in the expert's country. These median overall scores were then used as the response variable to understand the characteristics and drivers of bird trade expected for the future.

Explanatory variables

Two sets of variables were used to model trends in legal and illegal trade: a survey-derived predictor set representing trade characteristics identified by the experts (Table C.1,

Supplementary Material C); and a second predictor set with national-level socio-economic and environmental variables (Table 1). Given the large amount of potential predictor variables and the limited number of expert surveys, we undertook additional explorations in order to determine if any variables should be removed from further analysis.

Multiple correspondence analysis (MCA) and hierarchical clustering on principal components (HCPC) were performed on all survey-derived predictors in order to derive general descriptors of bird characteristics, consumer motivation and profile. Multiple correspondence analysis (MCA), an extension of correspondence analysis, analyses the pattern of relationships between several categorical (instead of quantitative) dependent variables (Kassambara 2017). HCPC is a form of hierarchical clustering performed using Ward's criterion on principal components derived from MCA or PCA (Kassambara 2017). MCA and HCPC were performed using package FactoMineR (Husson et al. 2015) in R 2.13.0 (R Core Team 2017).

The second predictor set was composed of 12 socio-economic and environmental variables compiled for all countries ($n = 53$) represented in our survey data (Table 1). Spearman correlation analysis was performed with function rcorr from package Hmisc (Harrell 2017) in R 2.13.0 (R Core Team 2017). This analysis indicated that these variables were not correlated (Table D.1, Supplementary material D); hence, all socio-economic and environmental predictors were included in subsequent analysis.

Factors affecting pet bird trade and expected future trends

To account for the ordered nature of the response variables (legal and illegal trade scores), ordinal regressions were fit to explore potential associations between explanatory variables and expected future trade trends in legal and illegal bird trade (our main variables of interest). This aimed to identify potential "trade hotspots" and inform specific interventions to be implemented based on a better understanding of country-level consumer demand and trade characteristics. Three model sets incorporating different explanatory variables were fit to analyse multiple aspects of legal and illegal trade expected for the near future. The first two model sets analysed survey answers: one model incorporated consumer motivations, preferred bird characteristics and buyer profile, and a second model set incorporated legislation effectiveness, level of enforcement, past trade, country perceived status (exporter, importer, both, neither) as explanatory variables; this dual-model approach was adopted for analysing survey-derived parameters due to the limited number of available responses ($n_{legal} = 56$; $n_{illegal} = 57$). Finally, a third model set was fit using national-level socio-economic and environmental predictors. To improve interpretation of ordinal regression outputs, each category present in the "Consumer motivation" and "Bird characteristics" variables was transformed into binary variables. This modelling approach was performed for legal and illegal trade separately.

Ordinal regressions were performed using package ordinal (Christensen 2015) in R 2.13.0 (R Core Team 2017). The relative importance of predictor variables on step selection was assessed for future legal and illegal trade separately, fitting all possible combinations of the selected covariates using function dredge from the MuMIn package (Bartoń 2014). In this case, the corrected AIC for small sample sizes (AICc) was used to perform model averaging (Hurvich and Tsai 1989) on a subset of models with a ΔAICc < 2 (as recommended by Burnham et al. 2002). Model averaged coefficients were extracted, along with their respective importance calculated as the sum of the Akaike weights over all

models in which that particular covariate is included, using function model.avg on package MuMIn (Bartoń 2014).

Expert's perceived versus documented illegal trade fluxes

To visualize perceived and recorded illegal international wild bird trade fluxes, a combined approach was adopted using R packages igraph (Csardi 2010) and ggplot 2 (Wickham 2015). On igraph, continents were used as nodes, and edges or links between each node (continents) were calculated using the number of responses considering each continent either a major importer or exporter, regarding the continent where the country of expertise was located. Arrow width was set as a representative of the number of experts considering each trade link important. Hence, thicker arrows characterising links among different continents represent especially important perceived trade avenues regarding the illegal trade of wild pet birds.

In order to quantify agreement between expert perceived and registered trade fluxes of illegally traded wild birds exported by each continent, we calculated Cohen's kappa. Kappa statistics measure interrater reliability, i.e. the extent to which different raters assign the same score to a variable. Contrary to the percent of agreement, Cohen's kappa accounts for chance agreement (McHugh 2012). Kappa statistics were performed with R package irr (Gamer et al. 2012).

## Challenges, consequences and solutions for illegal wild pet bird trade

In order to gain further insights into the challenges, consequences and proposed solutions to control illegal bird trade, experts were asked to provide up to three responses for each. To encourage more insightful answers, rather than pre-defined ones, questions were set up as open-ended. Once the data were collected, answers were subsequently categorised using an inductive approach, where summary themes were identified through the process of directly examining the data (Elo and Kyngäs 2008).

Results

Study participants

A total of 356 invitations were sent, 13 of which could not be fulfilled due to inactive or full inboxes and unavailable alternative contacts (non-contact rate = 3.7%). The survey was completed by 105 respondents (response rate = 31%). 71 participants answered all survey questions, with some missing data for the remaining 34 respondents; specific sample sizes for each question are reported throughout.

The respondents represented expertise related to bird trade in 53 countries located in Africa, Asia, Europe, South and Central America (Fig. 2). Most respondents were associated to NGOs, working on scientific research or program coordination at a national scale. The modal respondent was male, 24 to 54 years old (median = 35–44), with UK or USA citizenship, who has been working on the subject of bird trade for 5 to 10 years (median = 10, although 16 respondents had over 15 years of experience). A summary of the study participants is presented in Table E.1 (Supplementary material E).
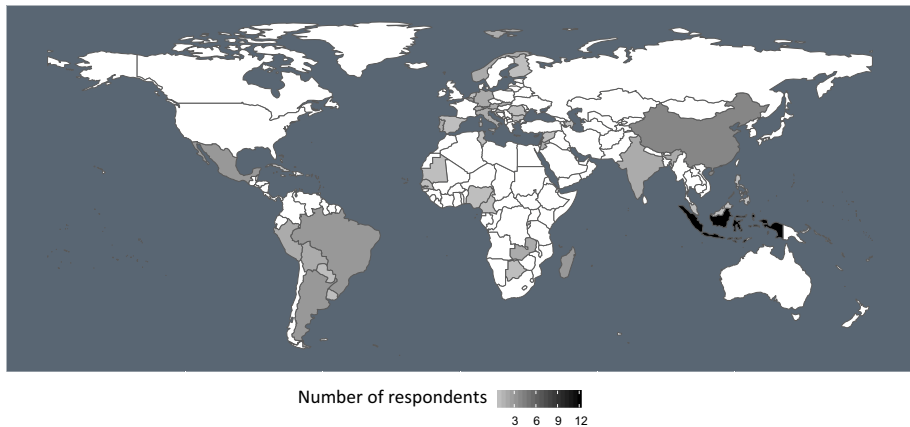
Fig. 2 Distribution of survey respondents (N = 102) according to their country of expertise (i.e. single country they felt more familiar with regarding bird trade, research and/or conservation). Countries for which we had no survey respondents are represented as white

Preferred bird characteristics, consumer profile and motivations

According to MCA and HCPC analyses, the main motivations for buying birds are competition (e.g. song contests), financial (investment), and socio-cultural (e.g. to impress friends or family, or due to traditions) (Table F1, Supplementary material F). Preferred bird characteristics were its temperament, specific species identity (independently of its characteristics), rarity (e.g. endemic or threatened species, rare phenotypes) or popularity, and its price and ability to sing (Table F2, Supplementary material F). People buying birds as pets can be classified in three profiles: people of high socio-economic and educational backgrounds, living in cities and ranging between 26 and 64 years; people of low socio-economic and educational backgrounds, living in rural areas, either under 26 or over 64 years old; and people not defined by relevant sociodemographic, educational and age parameters (Table F3, Supplementary material F). This last group arose as a consequence of some experts considering that the provided sociodemographic, educational and age parameters are not relevant for describing buyers in their countries of expertise.

Hence, original survey-derived predictors or respective categories were combined accordingly. Consumer motivations were aggregated into a 3-category predictor (Competition; Financial; Socio-Cultural). Bird characteristics were classified into a 4-category predictor (Temperament; Species; Popularity/Rarity; Price/Song). Buyer profile—initially defined by buyer age, gender, socio-economic, educational and urban/rural backgrounds— was converted into a single predictor with 3 profiles, merging categories of the original predictors. Buyer profile 1 was defined by high socio-economic and educational backgrounds, association to urban environments and 26 to 64 years of age. Buyer profile 2 was defined by low socio-economic and educational backgrounds, association with rural environments and other age groups (under 26 and over 64 years old). Buyer profile 3 was defined by not relevant sociodemographic, educational and age parameters.

Expected legal trade

Our results suggest that, based on experts' insights, legal pet bird trade is expected to increase in 15 of the 37 countries represented, especially in Indonesia. Variation in the level of change in future legal trade is best explained by the intentional purchase of wild-caught birds due to socio-cultural motivations, and bird popularity/rarity. Level of law enforcement, EU ban importance and perceived trends in legal trade in the past are also considered important predictors. Percentage of rural population is the main socio-economic predictor (Table 2 and G.1 from the Supplementary Material G) affecting variation in expected legal trade. Number of bird species threatened, bird species density and corruption perception index were also included in the top models but received less support.

Experts who expect legal pet bird trade to decrease in their country of expertise consider that consumers buy wild-caught birds intentionally, believe law to be enforced and the EU ban important for regulating bird trade. On the other hand, experts predicting legal trade to increase in their country of expertise consider most consumers buy wild-caught birds as pets due to socio-cultural motivations and bird popularity. An expected increase in future legal trade is associated with higher percentages of rural population.

Expected illegal trade

Our results suggest that, based on experts' expectations, illegal pet bird trade is expected to increase in 17 of the 37 countries represented, especially in Indonesia, Brazil and Slovakia. Future illegal trade is best explained by a demand for birds based on their popularity and of particular species, and a consumer profile characterized by higher socio-economic and educational backgrounds. Past illegal trade is another important predictor of illegal trade expected for the near future, as is human population growth rate. GINI index and GDPpc were also included in the top models but with less support (Table 2 and G.1 from the Supplementary Material G).

Experts who predict illegal pet bird trade to increase in their country of expertise consider that consumers buy pet birds due to their popularity and particular species identity. These experts also indicated that the typical buyer of illegally traded birds in countries where they expect this trade to increase in the future are 26 to 64 years old, come from higher socio-economic and educational backgrounds, and urban areas. Regarding socio-economic and environmental parameters, human population growth rate is associated with an expected increase in future illegal trade, as is an increased GINI index, though with less support.

Expert's perceived versus recorded trade fluxes

A total of 59 experts provided information on the main sources and destinations of illegally traded wild pet birds worldwide. 18 experts considered their country of expertise to be mainly an importer, 19 mainly an exporter, and 22 both an importer and exporter of illegally traded wild birds. Agreement between experts' perception and CITES reports on confiscations and seizures was highly variable depending on the continent considered, with moderate to good agreement on exports from North America (kappa = 0.645, p < 0.01), Europe (kappa = 0.565, p < 0.01) and Africa (kappa = 0.443, p < 0.01), and

Table 2 Model averaged coefficients estimates, adjusted standard errors, relative importance and p value for future legal and illegal trade models fitted according to: (a) consumer motivation, purchase, preferred bird characteristics, buyer profile; (b) legislation effectiveness, level of enforcement and past trade; and (c) socio-economic and environmental parameters. Model averaging was performed on a subset of models with ΔAICc <2

Trade		Variable	Estimate	Adjusted std. error	Relative importance	Pr(>|z|)
Legal trade in the future	(a)	Purchase: intentional	−1.460	0.626	0.80	0.019
		Consumer motivation: socio-cultural	0.707	0.683	0.40	0.030
	(b)	Bird characteristic: popularity	0.613	0.597	0.27	0.034
		Level of law enforcement: enforced	−1.760	0.634	0.30	0.044
		Past legal trade	4.753	1.351	0.74	0.003
		EU ban: important	−1.618	0.500	0.42	0.051
	(c)	Rural population (%)	0.658	0.329	0.90	0.045
		Species threatened (%)	0.531	0.342	0.54	0.032
		Corruption perception index	0.531	0.211	0.39	0.041
		Bird species density	0.373	0.258	0.36	0.015
Illegal trade in the future	(a)	Bird characteristic: popularity	1.521	0.501	1.00	0.013
		Buyer profile: 1	1.903	0.530	1.00	0.040
		Bird characteristic: species	0.709	0.651	0.20	0.027
	(b)	Level of law enforcement: enforced	−1.421	0.766	0.55	0.063
		Past illegal trade	4.739	1.322	1.00	<0.001
	(c)	Population growth rate	0.702	0.275	1.00	0.010
		GINI	0.261	0.234	0.14	0.040
		GDP*pc*	−0.246	0.254	0.12	0.051

Reference level for Consumer Purchase was "Accidental as much as Intentional", for Buyer Profile was "Profile 3", for Level of enforcement was "Not Enforced", and for EU Ban was "Not Important". Both Past legal and illegal trade are ordinal variables with 4 levels

poor agreement regarding exportations from South America (kappa = 0.105, p < 0.01) and Asia (kappa = 0.006, p < 0.01).

According to experts' perceptions, the continents that illegally export the majority of wild birds are Asia and South America (Fig. 3). Asia is perceived to export mainly to Europe and the Asian market. Africa is regarded mainly as an exporter to Europe, Asia and the African market. Australia is mostly considered an exporter to North America. Europe and the Middle East are mainly perceived as exporters as well as importers of illegally traded wild birds.

CITES reports North America as an important exporter of illegal wild birds, alongside Asia and South America (Fig. 4). The same data indicate North America as the main importer of illegal wild birds from Asia. Africa is as an exporter as well as an importer. Australia is reported as a relevant importer of illegal wild birds from North America. Bird trade records corroborate experts' judgement regarding Europe and the Middle East, which act as exporters and importers of illegal wild bird trade.

Legislation type and effectiveness

Most respondents (95%) stated that their country of expertise has some kind of restrictions regarding the capture and trade of wild birds (Table 3). These restrictions are mostly implemented through national actions (91%), corresponding mainly to legislations/regulations (99%). The effectiveness of national and local restrictions in controlling illegal bird trade was mostly regarded as "ineffective" (32%) or "moderately"/"somewhat effective" (28 and 30%, respectively). Enforcement of restrictions on illegal bird trade in their countries of expertise was mainly considered "somewhat enforced" (51%), followed by "moderately enforced" (21%) and "not enforced" (17%).
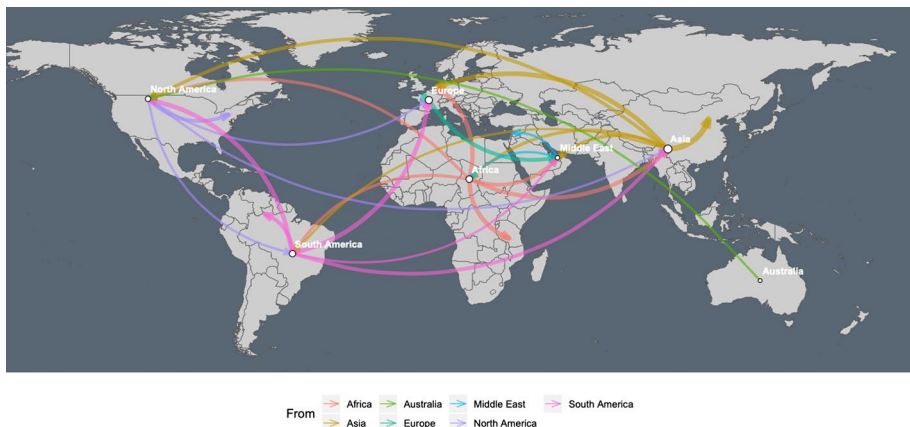
Fig. 3 Trade fluxes perceived by experts, considering whole continents. Arrow width is proportional to number of experts referring a given continent as a major exporter or importer, regarding their country of expertise in bird trade. Domestic trade is represented with arrows directed towards the same continent of export, without focusing particular countries. Information provided by 59 experts, who stated perceived exports destination and imports origin, totalizing to 128 answers, as this was an open-ended question, and multiple continents could be mentioned by a single expert
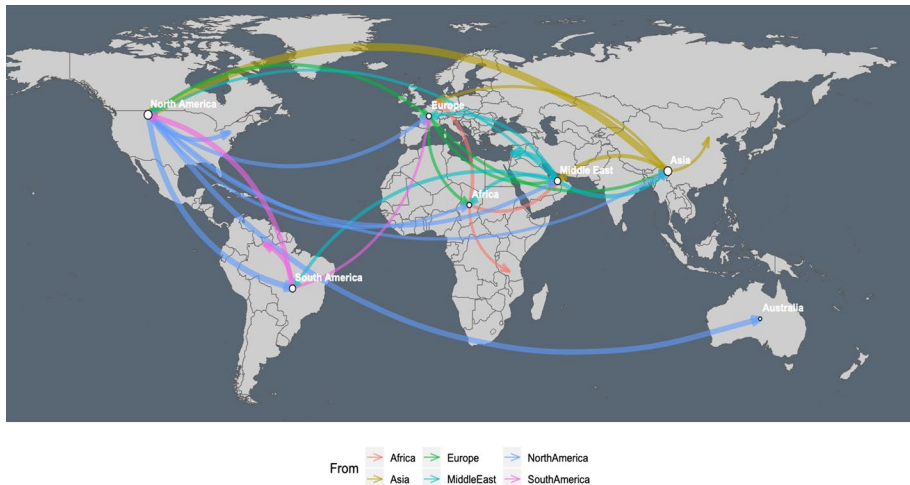
Fig. 4 Illegal trade fluxes gathered from the CITES Trade Database, regarding live wild-caught birds and considering whole continents. Arrow width is proportional to the amount of birds reportedly traded between continents. Domestic trade is represented by arrows directed towards the same continent of export, without regarding particular countries. Information based on data gathered during the period 2006–2016, involving all CITES Parties

The implementation of the 2005 EU ban on importations of wild birds was considered mostly "not important" (24%), followed by "moderately important" (21%) and "slightly important" (17%) for regulating bird trade in their country. Accordingly, most experts working in European countries considered the EU ban either "not important" (21%) or "moderately important" (19%), while 9% considered it only "slightly important" or even "not important" for regulating bird trade. CITES effectiveness for controlling the illegal bird trade was regarded as only "moderately" (38%) or "slightly effective" (32%).

Challenges, consequences and solutions for illegal wild pet bird trade

According to experts, the main challenges in reducing illegal bird trade were the limitations in legislation enforcement, monitoring and assessing illegal trade, and a lack of environmental awareness among stakeholders. The main potential consequence of illegal bird trade is biodiversity loss. Increased enforcement and environmental awareness appear to be the main solutions proposed to tackle illegal bird trade (Table 4).

Discussion

Globalized wildlife markets, with broad trade routes and increased trade volumes, can contribute to further increase the demand for wild-caught birds as pets, fuelling all potential consequences of wildlife trade in the future (Reino et al. 2017). Our study on perceived characteristics of both legal and illegal wildlife trade at a global scale focusing on consumer demand provides a better understanding of the potential national and international

Table 3 Count and relative frequencies of expert's responses for each question regarding legislation type, enforcement and effectiveness in their country of expertise

Question	Answer	Count	Relative frequency (%)
Are there restrictions regarding the capture and trade of wild birds? (N=77)	Yes	73	94.8
	No	3	3.9
	Don't know	1	1.3
How are these restrictions implemented? (N=77)	International actions	30	43.5
	National actions	63	91.3
	Local actions	36	52.2
Which type of actions are currently in place in this country regarding the capture and trade of wild birds? (N=77)	Legislations/regulations	69	98.6
	Codes of conduct	12	17.1
	Agreements	19	27.1
	Voluntary	11	15.7
	Others	4	5.7
Are national and local restrictions effective in controlling illegal bird trade? (N=71)	Very effective	2	2.8
	Effective	5	7.0
	Moderately effective	20	28.2
	Somewhat effective	21	29.6
	Ineffective	23	32.4
Level of law enforcement related to national and local restrictions in controlling illegal bird trade (N=70)	Strongly enforced	1	1.4
	Enforced	6	8.6
	Moderately enforced	15	21.4
	Somewhat enforced	36	51.4
	Not enforced at all	12	17.1

Table 3 (continued)

Question	Answer	Count	Relative frequency (%)
Was the EU ban important in affecting changes in bird trade? (N=72)	Extremely important	14	19.4
	Moderately important	15	20.8
	Neutral	5	6.9
	Slightly important	12	16.7
	Not at all important	17	23.6
	I was not aware of this trade ban	9	12.5
Effectiveness of CITES in controlling illegal bird trade in this country (N=73)	Extremely effective	3	4.1
	Moderately effective	28	38.4
	Neutral	5	6.8
	Slightly effective	23	31.5
	Not at all effective	13	17.8
	Not aware of CITES	1	1.4

Number of answers presented for each question. Respondents could choose multiple options regarding restriction types

Table 4 Percentage and frequency of responses for each challenge, consequence and solution suggested by a total of 69 surveyed experts

Aspects	Count	Responses (%)
Challenges		
Law enforcement issues	43	30.9
Monitoring and assessment	23	16.5
Environmental awareness	16	11.5
Capacity building	12	8.6
Legislation	12	8.6
Cultural aspects	11	7.9
Financial	5	3.5
Corruption	5	3.5
Institutional inertia	4	2.8
Consumer demand	4	2.8
Easy access	2	1.4
Consequences		
Biodiversity loss	67	55.3
Introduction of exotic invasive species	11	9.0
Other illegal behaviours	10	8.2
Increased consumer demand	7	5.7
Diseases	5	4.1
Ecosystem change	4	3.3
Behavioural impacts	3	2.4
Poor animal welfare	3	2.4
Unsustainable unregulated harvest	2	1.6
Negative financial impacts	1	0.8
Habitat destruction	1	0.8
Solutions		
Enforcement	62	34.0
Environmental awareness	37	20.3
Legislation	15	8.2
Monitoring and assessment	14	7.6
Capacity building	13	7.1
Consumer behaviour change	11	6.0
Certification	9	4.9
Trade bans	5	2.7
Promote alternative livelihoods	4	2.1
Conflict management	3	1.6
Advocacy	3	1.6
Address corruption	2	1.0
Accountability	1	0.5

Respondents could mention up to three issues to open-ended questions regarding main perceived challenges, consequences and possible solutions referring to illegal bird trade in their country of expertise. Issues were posteriorly identified based on thematic coding

drivers of wild bird trade, which can then be used to target and improve management and conservation strategies.

Potential trends and predictors of bird trade

According to our results, both legal and illegal trade is expected to increase in Indonesia, the world's largest archipelago and a megadiverse country, with high bird diversity, complex evolutionary history and high economic growth projected for the next decades (OECD 2014). Illegal trade is also expected to increase in Brazil and Slovakia. While expectations for Brazil can also be explained by its megadiverse country status, the emergence of Slovakia may be explained by the country's part in the European illegal trade of wildlife or derived products (Milliken 2014).

In order to ascertain potential trends, and predictors of domestic and international bird trade, we collected both national-level socio-economic and environmental data, as well as detailed consumer profiles from expert-based survey data. The goal was to improve our understanding of the multiple drivers of bird trade across countries, and identify potential targets for trade management. Detailed demographic profiles of bird owners are scarce, and impede the development of demographically targeted social marketing and conservation actions (Jepson and Ladle 2005). Our study suggests that both consumer characteristics (i.e. educational and socio-economic background) and wildlife product features (namely popularity and species identity) are important predictors of expected trade trends in the near future (i.e. next 5 years). Furthermore, we found that the interplay between these factors was different for the legal and illegal trade. Whereas consumers coming from higher socio-economic and educational backgrounds, and urban environments were strongly linked to expectations of increased illegal wild-caught bird trade, we were not able to distinguish profiles for consumers of legally traded pet birds. This might suggest that, for legally traded products, there is a social transversality of the fondness for pet birds, but illegally traded birds are a niche product. Indeed, Courchamp et al. (2006) found that CITES-listed species were significantly more expensive than non-CITES listed species, probably as a consequence of their rarity, further advertised through their CITES listing. Consumers place higher value on wildlife or wildlife-derived goods when they are considered rare or uncommon (Chen 2016). Hence, buyers with higher socio-economic status are more likely to be able to afford these items. This, in turn, might drive both price and demand even higher.

Consumer motivations might also contribute to a better understanding of purchase behaviour and help define interventions. Increased expected future legal trade appears associated with both intentional purchase and socio-cultural motivations for buying wild-caught birds. The use of birds as pets is a tradition with deep cultural roots, especially in Central (Roldán-Clarà et al. 2017) and South America (da Alves et al. 2010), Asia (Su et al. 2015) and the circum-Mediterranean region (Brochet et al. 2016). Generally, birds are kept as pets because of their beauty, lively colouration, melodious songs, ability to imitate words, attachment to humans, or several of these reasons combined. However, in Asia there are many other cultural practices related to pet birds, such as prayer release, singing competitions, and 'bird-walking' (the avian equivalent of dog-walking, where birds are taken out in cages for fresh air) (Su et al. 2015). Burivalova et al. (2017) concluded that the main reason why people intentionally bought wild birds as pets was the high cost of captive-bred birds, and a perception that captive-bred birds do not sing as well as wild-caught ones. This suggests the need for consumer-focused demand reduction actions, coupled with increased

offer of captive-bred birds as a more sustainable alternative source (Jepson and Ladle 2005). A more detailed assessment of consumer and market characteristics at regional and national levels would allow targeting trade reduction campaigns towards the profile of consumers that most influence trade (Veríssimo and Wan 2018).

Understanding which bird characteristics are more in demand by consumers is crucial for identifying species with increased probability of being traded, which, in turn, contributes to the development of early interventions targeting the protection of the most vulnerable species. Our results suggest that bird popularity tends to be the most important characteristic preferred by legal and illegal bird consumers, especially when both legal and illegal trades are expected to increase. Experts also consider species particular identity to be an important characteristic for consumers when illegal trade is expected to increase in their country of expertise. Demand for pet birds based on their popularity or particular species identity may be determined by media-fuelled trends. For example, in recent decades, a substantial number of popular press articles have described an increase in demand for certain species in the pet trade due to films such as "Finding Nemo", "Ninja turtles", and "Harry Potter" (Megias et al. 2017). Despite such allegations being largely supported by anecdotal evidence, there is ample evidence that the demand for particular species whose popularity is associated to certain physical traits or rarity is related to overexploitation, as with the yellow-crested cockatoo (*Cacatua sulphurea*) or the African grey parrot (*Psittacus erithacus*) (Tella and Hiraldo 2014; Eaton et al. 2015; Harris et al. 2015). From a market perspective, the increasing rarity of some species might make them even more attractive to consumers, thus increasing their risk of extinction through an anthropogenic Allee effect (Courchamp et al. 2006). This may suggest that the cultural roots of the demand for wild pet birds may be replaced by potentially more manageable and predictable fashion/trend-based aspects, often driven by the media.

From our survey, it also emerged that bird song, often listed as a worldwide favourite trait in pet birds (Blackburn et al. 2014), did not figure as important when compared to bird popularity or species identity. In addition, our results did not identify a preference for wild birds (instead of captive-bred individuals), or for native/non-native species, suggesting preferred characteristics do not appear intrinsically linked to the bird's origins, but to other traits. Although one of the main consumer motivations for consumers who want to specifically buy wild birds is their wild origin, generic buyers searching for pet birds do not appear to prefer wild-caught specimens. This reinforces the potential of promoting captive-breeding for supplying general demanders of pet birds, because although previously reported as a desired trait in some countries, wild birds may be more often purchased accidentally than on purpose (Burivalova et al. 2017).

Socio-economic aspects at the national level play an important role in wildlife trade (da Alves et al. 2010). Our survey indicates that increases in expected illegal trade seem to be positively linked to increases in human population growth rates and number of threatened bird species. This implies that countries with faster population growth rates will likely become more important actors in bird trade. Worryingly, many of these fast-growing countries are rich in biodiversity, and higher levels of bird trade may impose strong pressures on their natural resources. Increased rural population and bird species threatened appear associated with increased legal trade expected for the future. In developing countries, with large rural populations and higher percentage of bird species threatened, local communities sometimes strongly depend on trading native biodiversity as a profitable economic activity (Brashares et al. 2011). International agreements such as the Convention on Biological Diversity (CBD) or CITES resolutions Conf 8.3 or 16.6 reinforce the importance of promoting sustainable use of biological diversity and recognizing the rights of

people to benefit from their use (Convention on International Trade in Endangered Species 2016). However, overexploitation for wildlife trade is a major threat for wildlife, including birds (Bush et al. 2014). The case of parrots (Order Psittaciforme) is particularly concerning, as their popularity has lead at least 259 species to be commercialized worldwide, involving millions of individuals traded in recent decades (Beissinger 2001). Although more detailed studies on the effects of parrot trade on wild populations and harvesting sustainability are lacking, wildlife trade is thought to have contributed to nearly 30% of the 355 species of parrots being currently threatened with extinction (Donald et al. 2010). Furthermore, according to Berkunsky et al. (2017), capture for local pet trade is closely associated with decreasing population trends in parrots. Thus, if uncontrolled, wildlife harvesting may become unsustainable, threaten wildlife populations, ecosystems (Duffy et al. 2014; Robinson et al. 2018; UNEP 2018) and human populations depending on it.

Trade fluxes and conservation impacts

Overall, trade fluxes perceived by experts match the fluxes of illegally traded birds recorded within the CITES framework. However, experts regard South America and Asia as the main exporters, while CITES records indicate North America as the most important supplier of illegally exported birds. In this case, North America may be acting as a distributer of trade coming illegally from South and Central America to the rest of the globe, thus masking the true source of illegally traded birds. In addition, CITES confiscations of illegal trade are more likely to occur in North America, where it is more strongly enforced, than in South American or Asian countries.

Using CITES data, Bush et al. (2014) also identified Southeast Asia and South America as important exporters and importers of exotic pets, the Middle East as another major driver of the exotic pet market, and Africa as a source of exotic pets. However, according to the experts' judgement and CITES records, Africa and the Middle East act as both exporters and importers of illegally traded birds, which may be partially explained by the emergence of several African economies, e.g. Nigeria (United Nations DESA/Population Division 2017). Although CITES records of illegally traded birds are likely an underrepresentation of reality, this redirection of trade from developed countries, where knowledge and resources to manage invasive species are available and social awareness is high, towards developing countries, which are less well equipped to deal with invasions, may contribute increasing invasion risks and consequent impacts on native species (Cardador et al. 2017; Reino et al. 2017). Furthermore, with expanding trade networks and environmental change incorporating new regions into the pool of potential alien species, and estimates of 1–16% of all species on Earth qualifying as potential established alien species, future impacts are difficult to predict (Seebens et al. 2018).

Legislation effectiveness, perceived challenges and solutions

Our study suggests that enforcement of current legislation remains a critical issue in wildlife trade. Although most respondents stated that their country had legal restrictions on the capture and trade of wild birds, we found a general feeling of suspicion about their effectiveness (e.g. EU ban, CITES and national regulations), despite moderate levels of enforcement. However, perceived level of enforcement was an important factor in determining whether legal and illegal trade would increase or decrease, i.e. experts expecting a decrease in bird trade (legal and illegal) also perceived existing laws to be enforced. The

main challenges in reducing illegal bird trade in each respondent's country of expertise were difficulties associated to law enforcement, monitoring and assessing illegal trade, as well as a lack of environmental awareness among key stakeholders. Edmunds et al. (2011) has already demonstrated that many stakeholders are unaware of trade regulations. Challender et al. (2015) also linked CITES' inefficiency to Parties' non-compliance, scarce knowledge and/or capacity to monitor listed species (UNEP-WCMC 2014). This is due to several deeply imbedded socio-economic and cultural reasons unlikely to change in the foreseeable future. Our survey respondents proposed both increased law enforcement and enhanced environmental awareness as the main solutions for reducing illegal bird trade. While these solutions are likely to benefit from a wide range of initiatives, including demand reduction campaigns, better trade assessments and improved governance at national levels (Challender et al. 2015), it has been increasingly acknowledged that enforcement and regulations are insufficient on their own. Efforts should be concentrated towards strengthening enforcement (and management) in countries where trade is expected to increase, but also increasing controls to make enforcement and management effective and integrating local populations in wildlife conservation and management through, e.g. captive-breeding campaigns, sustainable harvest programs or ecotourism.

Although one of the main consumer motivations for purposely buying wild birds was precisely their wild origin, most people who want to buy pet birds do not appear to prefer wild-caught specimens, instead being mainly stimulated to buy pet birds due to their perceived popularity, rarity or particular species identity. Hence, captive-breeding can potentially be a viable option for supplying average demanders of pet birds, who may be buying wild birds inadvertently. These policies should be implemented for all traded bird species, with increased efforts targeted at species recognized as highly fashionable due to their popularization in the media. This might be especially welcomed and effective in countries with increased rural population and bird species threatened—where legal trade is expected to increase—as it might act as a potential income source for local populations, while alleviating extractive pressure from wild bird populations. Furthermore, countries with historical socio-cultural traditions of birdkeeping (Central/South America and Asia) should be especially committed to invest in these interventions, as their legal trade is also expected to increase in the future. Likewise, countries with faster population growth rates [e.g. Nigeria, Democratic Republic of the Congo (United Nations DESA/Population Division 2017)] will likely experience increased illegal bird trade, and thus should also prioritize actions aiming at controlling illegal trade, targeting awareness campaigns towards profiled consumers (higher socio-economic and educational backgrounds, and urban environments).

Whilst recognising the potential limitations of expert knowledge, e.g. from bias or poor calibration leading to poor inference and decision making (Drescher et al. 2013; Kuhnert 2011), it is often the only tool to explore complex and urgent issues often impaired by limited resources (Kuhnert et al. 2010; Martin et al. 2012; Pullin et al. 2016), such as our study. We relied on knowledge of academic and NGO experts who could convey their perceptions on bird trade, including insights on industry, sellers and bird keepers. We acknowledge the limitations of our approach and that additional information might be gained through the expansion of this survey to other audiences, such as industry and bird-keeping community representatives, now identified as a key aspect for future research.

We recognize that the modest coverage of countries represented in our study (N = 53) might hamper quantitative inferences from our results. Furthermore, the fact that most experts were either Europeans or North Americans working in NGOs scattered worldwide may be another limitation of our study. Also, our questionnaire was implemented in English, which we accepted as inevitable to ensure the global character coverage of the survey.

Notwithstanding, the considerable expertise reported by the respondents gives credibility to our qualitative conclusions. Here we present an analysis of the global trends of legal and illegal wild pet birds trade that should serve as the basis for future studies. Investigating the multidimensional and highly interacting determinants of wildlife trade will thus help inform conservation action towards trade-threatened species in the long-term.

References

Abellán P, Carrete M, Anadón JD et al (2016) Non-random patterns and temporal trends (1912–2012) in the transport, introduction and establishment of exotic birds in Spain and Portugal. Divers Distrib 22:263–273. https://doi.org/10.1111/ddi.12403

Auliya M, Altherr S, Ariano-Sanchez D et al (2016) Trade in live reptiles, its impact on wild populations, and the role of the European market. Biol Conserv 204:103–119

Barnes MD, Craigie ID, Harrison LB et al (2016) Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. Nat Commun 7:12747. https://doi.org/10.1038/ncomms12747

Bartoń K (2014) MuMIn: multi-model inference. R package version 1.10.5. R Packag

Beissinger SR (2001) Trade of live wild birds, principles and practices of sustainable use. In: Reynolds JD, Mace GM, Robinson JG (eds) Conservation of exploited species. Cambridge University Press, Cambridge, pp 183–202

Berkunsky I, Quillfeldt P, Brightsmith DJ et al (2017) Current threats faced by Neotropical parrot populations. Biol Conserv 214:278–287. https://doi.org/10.1016/j.biocon.2017.08.016

BirdLife International (2008) Nearly half of all bird species are used directly by people. In: BirdLife State of the world's birds website. http://www.birdlife.org/datazone/sowb/casestudy/98

BirdLife International (2015) Wild bird trade and CITES. In: BirdLife Int. http://www.birdlife.org/worldwide/policy/wild-bird-trade-and-cites

Blackburn TM, Su S, Cassey P (2014) A potential metric of the attractiveness of bird song to humans. Ethology 120:305–312. https://doi.org/10.1111/eth.12211

Brashares JS, Golden CD, Weinbaum KZ et al (2011) Economic and geographic drivers of wildlife consumption in rural Africa. Proc Natl Acad Sci USA 108:13931–13936. https://doi.org/10.1073/pnas.1011526108

Brenton-Rule EC, Barbieri RF, Lester PJ (2016) Corruption, development and governance indicators predict invasive species risk from trade. Proc R Soc B Biol Sci 283:20160901. https://doi.org/10.1098/rspb.2016.0901

Brochet AL, Van Den Bossche W, Jbour S et al (2016) Preliminary assessment of the scope and scale of illegal killing and taking of birds in the Mediterranean. Bird Conserv Int 26:1–28. https://doi.org/10.1017/S0959270915000416

Burgman M, Carr A, Godden L et al (2011) Redefining expertise and improving ecological judgment. Conserv Lett 4:81–87

Burivalova Z, Lee TM, Hua F et al (2017) Understanding consumer preferences and demography in order to reduce the domestic trade in wild-caught birds. Biol Conserv 209:423–431. https://doi.org/10.1016/j.biocon.2017.03.005

Burnham KP, Anderson DR, Anderson KP, Burnham DA (2002) Model selection and multimodel inference: a practical information-theoretic approach, 2nd edn. Springer, New York

Bush ER, Baker SE, Macdonald DW (2014) Global trade in exotic pets 2006–2012. Conserv Biol 28:663–676. https://doi.org/10.1111/cobi.12240

Cardador L, Lattuada M, Strubbe D et al (2017) Regional bans on wild-bird trade modify invasion risks at a global scale. Conserv Lett 10:717–725. https://doi.org/10.1111/conl.12361

Cardador L, Tella J, Anadón J, Carrete M (2019) The European trade ban on wild birds reduced invasion risks. Conserv Lett 12:e12631

Carrete M, Tella JL (2008) Wild-bird trade and exotic invasions: a new link of conservation concern? Front Ecol Environ 6:207–211. https://doi.org/10.1890/070075

Challender DWS, MacMillan DC (2014) Poaching is more than an enforcement problem. Conserv Lett 7:484–494. https://doi.org/10.1111/conl.12082

Challender DWS, Harrop SR, MacMillan DC (2015) Towards informed and multi-faceted wildlife trade interventions. Glob Ecol Conserv 3:129–148. https://doi.org/10.1016/j.gecco.2014.11.010

Challender D, Hinsley A, Milner-Gulland E (2019) Inadequacies in establishing CITES trade bans. Front Ecol Environ 17(4):199–200

Chan HK, Zhang H, Yang F, Fischer G (2015) Improve customs systems to monitor global wildlife trade. Science 348:291–292. https://doi.org/10.1126/science.aaa3141

Chen F (2016) Poachers and snobs: demand for rarity and the effects of antipoaching policies. Conserv Lett 9:65–69

Chng SCL, Eaton JA, Krishnasamy K et al (2015) In the market for extinction: an inventory of Jakarta's bird markets. Petaling Jaya, Selangor

Christensen R (2015) Package "ordinal"—regression models for ordinal data version 2015.6-28. Cran

Commission European Communities (2007) Commission Regulation (EC) No 318/2007 of 23 March 2007 layind down animal health conditions for imports of certain birds into the Community and the quarantine conditions thereof [cited 12 July 2015]. http://eur-lex.europa.eu/legal-content. Off J Eur Union, pp 7–29

Convention on International Trade in Endangered Species (2016) Convention on International Trade in Endangered Species (CITES)

Cooney R, Jepson P (2006) The international wild bird trade: what's wrong with blanket bans? Oryx 40:18–23. https://doi.org/10.1017/S0030605306000056

Courchamp F, Angulo E, Rivalan P et al (2006) Rarity value and species extinction: the anthropogenic allee effect. PLoS Biol 4:2405–2410. https://doi.org/10.1371/journal.pbio.0040415

Csardi G (2010) Package 'igraph'. Cran. https://doi.org/10.1177/001316446902900315

da Alves RR, Nogueira EE, Araujo HFP, Brooks SE (2010) Bird-keeping in the Caatinga, NE Brazil. Hum Ecol 38:147–156. https://doi.org/10.1007/s10745-009-9295-5

da Alves RR, Lima JR, Araujo HFP (2013) The live bird trade in Brazil and its conservation implications: an overview. Bird Conserv Int 23:53–65

Department for Environment, Food & Rural Affairs, Department for International Development HO (2014) Declaration London conference on the illegal wildlife trade 12–13 February 2014. In: Declaration London Conference on the Illegal Wildlife Trade. London, p 8

Donald PF, Collar NJ, Marsden SJ, Pain DJ (2010) Facing extinction. T & AD Poyser, London

Doukakis P, Pikitch EK, Rothschild A et al (2012) Testing the effectiveness of an international conservation agreement: marketplace forensics and CITES Caviar trade regulation. PLoS ONE 7:e40907. https://doi.org/10.1371/journal.pone.0040907

Drescher M, Perera AH, Johnson CJ et al (2013) Toward rigorous use of expert knowledge in ecological research. Ecosphere 4(7):1–26. https://doi.org/10.1890/ES12-00415.1

Duffy R, St John FAV, Büscher B, Brockington D (2014) The militarization of anti-poaching: undermining long term goals? Environ Conserv 42:345–348

Eaton JA, Shepherd CR, Rheindt FE et al (2015) Trade-driven extinctions and near-extinctions of avian taxa in Sundaic Indonesia. Forktail 31:1–12

Edmunds K, Roberton SI, Few R, et al (2011) Investigating Vietnam's ornamental bird trade: Implications for transmission of zoonoses. Ecohealth 8:63–75. https://doi.org/10.1007/s10393-011-0691-0

Elo S, Kyngäs H (2008) The qualitative content analysis process. J Adv Nurs 62:107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Essl F, Bacher S, Blackburn TM et al (2015) Crossing frontiers in tackling pathways of biological invasions. Bioscience 65:769–782. https://doi.org/10.1093/biosci/biv082

Faugier J, Sargeant M (1997) Sampling hard to reach populations. J Adv Nurs 26:790–797. https://doi.org/10.1046/j.1365-2648.1997.00371.x

FEDIAF (2018) Number of pet animals in Europe in 2017, by animal type (in 1000 s). In: Stat.—Stat. Portal. https://www.statista.com/statistics/453880/pet-population-europe-by-animal/. Accessed 19 Nov 2018

Fleming P, Meek P, Banks P et al (2014) Camera trapping: wildlife management and research. Csiro Publishing, Collingwood

Gamer M, Lemon J, Fellows I, Singh P (2012) Various coefficients of interrater reliability and agreement. Cran. https://cran.r-project.org/package=irr%0A

Guyer C, Robinson JG, Redford KH (1992) Neotropical wildlife use and conservation. J Wildl Manag 56:622. https://doi.org/10.2307/3808886

Haenlein C, Smith MLR (2017) Poaching, wildlife trafficking and security in Africa: myths and realities. Routledge, London

Haken J (2011) Transnational crime in the developing world. Glob Financ Integer. https://doi.org/10.1080/01924036.2015.1028951

Harrell FE (2017) CRAN—Package Hmisc. Hmisc Harrell Misc

Harris JBC, Green JMH, Prawiradilaga DM et al (2015) Using market data and expert opinion to identify overexploited species in the wild bird trade. Biol Conserv 187:51–60. https://doi.org/10.1016/j.biocon.2015.04.009

Hulme PE (2009) Trade, transport and trouble: managing invasive species pathways in an era of globalization. J Appl Ecol 46:10–18. https://doi.org/10.1111/j.1365-2664.2008.01600.x

Hurvich CM, Tsai CL (1989) Regression and time series model selection in small samples. Biometrika 76:297–307. https://doi.org/10.1093/biomet/76.2.297

Husson AF, Josse J, Le S, et al (2015) Package 'FactoMineR.' FactoMineR

Jamieson S (2004) Likert scales: how to (ab)use them. Med Educ 38:1217–1218

Jenkins P (2007) Broken screens: the regulation of live animal imports in the United States. Defenders of Wildlife, Washington

Jepson P, Ladle RJ (2005) Bird-keeping in Indonesia: conservation impacts and the potential for substitution-based conservation responses. Oryx 39:442–448. https://doi.org/10.1017/S0030605305000110

Karesh WB, Cook RA, Bennett EL, Newcomb J (2005) Wildlife trade and global disease emergence. Emerg Infect Dis 11:1000–1002

Karesh WB, Cook RA, Gilbert M, Newcomb J (2007) Implications of wildlife trade on the movement of avian influenza and other infectious diseases. J Wildl Dis 43:S55–59. https://doi.org/10.1016/S0016-5085(09)61555-9

Kassambara A (2017) Practical guide to principal component methods in R: PCA, M (CA), FAMD, MFA, HCPC, factoextra, vol 2. STHDA

Kuhnert PM (2011) Four case studies in using expert opinion to inform priors. Environmetrics 22:662–674. https://doi.org/10.1002/env.1115

Kuhnert PM, Martin TG, Griffiths SP (2010) A guide to eliciting and using expert knowledge in Bayesian ecological models. Ecol Lett 13:900–914

Martin TG, Burgman MA, Fidler F et al (2012) Eliciting expert knowledge in conservation science. Conserv Biol 26:29–38

Masanja GF (2014) Human population growth and wildlife extinction in Ugalla ecosystem, Western Tanzania George F. Masanja. J Sustain Dev Stud 5:192–217

McHugh ML (2012) Interrater reliability: the kappa statistic. Biochem Medica. https://doi.org/10.11613/BM.2012.031

Megias DA, Anderson SC, Smith RJ, Veríssimo D (2017) Investigating the impact of media on demand for wildlife: a case study of Harry Potter and the UK trade in owls. PLoS ONE 12:1–13. https://doi.org/10.1371/journal.pone.0182368

Milliken T (2014) Illegal trade in Ivory and Rhino Horn: an assessment report to improve law enforcement under the wildlife TRAPS project. USAID

Newing H (2010) Conducting research in conservation: social science methods and practice. Routledge, London

Nijman V (2010) An overview of international wildlife trade from Southeast Asia. Biodivers Conserv 19:1101–1114. https://doi.org/10.1007/s10531-009-9758-4

OECD (2014) Long-term baseline projections, No. 95 (Edition 2014)

Ostrom E, Nagendra H (2006) Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. Proc Natl Acad Sci USA 103:19224–19231. https://doi.org/10.1073/pnas.0607962103

Pe'er G, Zinngrebe Y, Hauck J et al (2017) Adding some green to the greening: improving the EU's ecological focus areas for biodiversity and farmers. Conserv Lett 10:517–530. https://doi.org/10.1111/conl.12333

Pullin A, Frampton G, Jongman R et al (2016) Selecting appropriate methods of knowledge synthesis to inform biodiversity policy. Biodivers Conserv 25:1285–1300. https://doi.org/10.1007/s10531-016-1131-9

Rabinovich J (2012) Parrots, precaution and project Elé: management in the face of multiple uncertainties. In: Cooney R, Dickson B (eds) Biodiversity and the precautionary principle. EarthScan, London, pp 173–188

Regueira RFS, Bernard E (2012) Wildlife sinks: quantifying the impact of illegal bird trade in street markets in Brazil. Biol Conserv 149:16–22. https://doi.org/10.1016/j.biocon.2012.02.009

R Core Team (2017) R: a language and environment for statistical computing (Version 3.4. 2) [Computer software]. Vienna, Austria: R foundation for statistical computing

Reino L, Figueira R, Beja P et al (2017) Networks of global bird invasion altered by regional trade ban. Sci Adv 3:e1700783. https://doi.org/10.1126/sciadv.1700783

Robinson JE, Sinovas P (2018) Challenges of analyzing the global trade in CITES-listed wildlife. Conserv Biol 32:1203–1206. https://doi.org/10.1111/cobi.13095

Robinson JE, Griffiths RA, Fraser IM et al (2018) Supplying the wildlife trade as a livelihood strategy in a biodiversity hotspot. Ecol Soc 23:13. https://doi.org/10.1111/jpr.12188

Roe D, Booker F (2019) Engaging local communities in tackling illegal wildlife trade: a synthesis of approaches and lessons for best practice. Conserv Sci Pract 1(5):e26

Roe D, Mulliken T, Milledge S et al (2002) Making a killing or making a living? Wildlife trade, trade controls and rural livelihoods. Biodivers Livelihoods 59:109

Roldán-Clarà B, Toledo VM, Espejel I (2017) The use of birds as pets in Mexico. J Ethnobiol Ethnomed 13:35. https://doi.org/10.1186/s13002-017-0161-z

Rosen GE, Smith KF (2010) Summarizing the evidence on the international trade in illegal wildlife. EcoHealth 7:24–32. https://doi.org/10.1007/s10393-010-0317-y

Seebens H, Blackburn TM, Dyer EE et al (2018) Global rise in emerging alien species results from increased accessibility of new source pools. Proc Natl Acad Sci USA 115(10):E2264–E2273. https://doi.org/10.1073/pnas.1719429115

Shepherd CR, Nijman V (2008) The trade in bear parts from Myanmar: an illustration of the ineffectiveness of enforcement of international wildlife trade regulations. Biodivers Conserv 17:35–42. https://doi.org/10.1007/s10531-007-9228-9

Simberloff D, Martin JL, Genovesi P et al (2013) Impacts of biological invasions: what's what and the way forward. Trends Ecol Evol 28:58–66. https://doi.org/10.1016/j.tree.2012.07.013

Smith KM, Anthony SJ, Switzer WM et al (2012) Zoonotic viruses associated with illegally imported wildlife products. PLoS ONE 7:e29505. https://doi.org/10.1371/journal.pone.0029505

Su S, Cassey P, Vall-Llosera M, Blackburn TM (2015) Going cheap: determinants of bird price in the Taiwanese pet market. PLoS ONE 10(5):0127482. https://doi.org/10.1371/journal.pone.0127482

Tella JL, Hiraldo F (2014) Illegal and legal parrot trade shows a long-term, cross-cultural preference for the most attractive species increasing their risk of extinction. PLoS ONE 9:e107546. https://doi.org/10.1371/journal.pone.0107546

TRAFFIC (2008) What's driving the wildlife trade? A review of expert opinion on economic and social drivers of the wildlife trade and trade control efforts in Cambodia, Indonesia, Lao PDR and Vietnam. In: East Asia and Pacific Region Sustainable Development Discussion Papers

UNEP (2018) Decision adopted by the conference of the parties to the convention on biological diversity. In: Conference of the parties to the convention on biological diversity. Sharm el-Sheikh, Egypt

UNEP-Interpol (2016) The rise of environmental crime—a growing threat to natural resources peace, development and security. A UNEP-INTERPOL rapid response assessment

UNEP-WCMC (2014) Analysis of the impact of EU decisions on trade patterns. Report 4: conclusions and recommendations

United Nations DESA/Population Division (2017) World population prospects: the 2017 revision—key findings and advance tables

Veríssimo D, Wan AKY (2018) Characterizing efforts to reduce consumer demand for wildlife products. Conserv Biol. https://doi.org/10.1111/cobi.13227

Wickham H (2015) ggplot2: an implementation of the grammar of graphics. R package version 0.7. http://CRAN.R-project.org/package=ggplot2,3

Williams A, Le Billon P (2017) Corruption, natural resources and development: from resource curse to political ecology. Edward Elgar Publishing, Cheltenham

Affiliations

Joana Ribeiro[1,2] 🟢 **· Luís Reino[1,2] · Stefan Schindler[3,4] · Diederik Strubbe[5] · Miquel Vall-llosera[6] · Miguel Bastos Araújo[7,8,9] · César Capinha[1,2] · Martina Carrete[10] · Sabrina Mazzoni[8] · Miguel Monteiro[1,2] · Francisco Moreira[1,2] · Ricardo Rocha[11] · José L. Tella[12] · Ana Sofia Vaz[1] · Joana Vicente[1] · Ana Nuno[13]**

✉ Joana Ribeiro
  joanatribeiro@cibio.up.pt; joanateixeiraribeiro@gmail.com

1   Laboratório Associado, CIBIO/InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Campus Agrário de Vairão, 4485-661 Vairão, Portugal

2   Laboratório Associado, CIBIO/InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisbon, Portugal

3   Environment Agency Austria, Spittelauer Lände 5, 1090 Vienna, Austria

4   Division of Conservation Biology, Vegetation and Landscape Ecology, University of Vienna, Rennweg 14, 1090 Vienna, Austria

5   Terrestrial Ecology Unit (TEREC), Ghent University, K.L. Ledeganckstraat 35, 9000 Ghent, Belgium

6   Institute of Mountain Science, Shinshu University, Matsumoto, Nagano, Japan

7   Department of Biogeography and Global Change, Museo Nacional de Ciencias Naturales, CSIC, Calle José Gutiérrez Abascal 2, 28006 Madrid, Spain

8   Rio Nabeiro Biodiversity Chair, Univ. de Évora, Largo dos Colegiais, Évora, Portugal

9   Center for Macroecology, Evolution and Climate, Natural History Museum of Denmark, Univ. of Copenhagen, Copenhagen, Denmark

10 Department of Physical, Chemical and Natural Systems, University Pablo de Olavide, Seville, Spain

11 Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge CB23EJ, UK

12 Department of Conservation Biology, Estación Biológica de Doñana, CSIC, Américo Vespucio 26, 41092 Seville, Spain

13 Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Penryn, Cornwall TR10 9FE, UK