



Global Trade in Exotic Pets 2006–2012

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Abstract: *International trade in exotic pets is an important and increasing driver of biodiversity loss and often compromises the standards required for good animal welfare. We systematically reviewed the scientific and gray literature and used the United Nations Environment Programme - World Conservation Monitoring Centre (UNEP-WCMC) Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) trade database to establish temporal and geographical trade patterns of live exotic birds, mammals, and reptiles and to describe trends in research, taxonomic representation, and level of threat and legal protection of species traded. Birds were the most species-rich and abundant class reported in trade; reptiles were second most abundant but unusually the most studied in this context; and mammals were least abundant in trade. Mammalian and reptilian species traded as pets were more likely to be threatened than expected by random. There have been a substantial number of Appendix I listed captive-bred mammals and birds and wild-caught birds and reptiles reported in trade to CITES. We identified the Middle East's emerging role as a driver of demand for exotic pets of all taxa alongside the well-established and increasing role of South America and Southeast Asia in the market. Europe, North America, and the Middle East featured most heavily in trade reports to CITES, whereas trade involving South America and Southeast Asia were given most emphasis in the literature. For effective monitoring of and appropriate response to the international exotic pet trade, it is imperative that the reliability and detail of CITES trade reports improve and that scientific research be directed toward those taxa and locations that are most vulnerable.*

Keywords: animal welfare, CITES, exotic pet trade, wildlife trade

El Mercado Global de Mascotas Exóticas 2006-2012

Resumen: *El mercado internacional de mascotas exóticas es un factor importante y creciente de pérdida de la biodiversidad y continuamente compromete los estándares requeridos para un buen bienestar animal. Sistemáticamente revisamos la literatura científica y gris y usamos la base de datos de mercados de UNEP-WCMC CITES para establecer patrones temporales y geográficos del mercado de aves, mamíferos y reptiles exóticos vivos y describir las tendencias en la investigación, la representación taxonómica y el nivel de amenaza y la protección legal de las especies comercializadas. Las aves fueron la clase con mayor riqueza de especies y la más abundante; los reptiles fueron la segunda más abundante pero inusualmente la más estudiada en este contexto; los mamíferos fueron los menos abundantes en el mercado. Las especies de mamíferos y reptiles comercializadas como mascotas tuvieron mayor probabilidad de estar amenazadas que lo esperado por el azar. Ha habido un número sustancial de especies de mamíferos y aves criados en cautiverio y listados en el Apéndice-I y de aves y reptiles capturados en vida silvestre reportados en el mercado a CITES. Identificamos el papel emergente del Oriente Medio como conductor de la demanda de mascotas exóticas de todos los taxones junto con el bien establecido y creciente papel de América del Sur y el Sureste Asiático en el mercado. Europa, América del Norte y el Oriente Medio figuraron más en los reportes de mercado hechos a CITES, mientras que al mercado en América del Sur y el Sureste Asiático se le dio más énfasis en la literatura. Para un monitoreo efectivo de y una respuesta apropiada al mercado internacional de mascotas exóticas, es imperativo que la confiabilidad y el detalle de los reportes de mercado de CITES mejoren y que la investigación científica sea dirigida hacia esos taxones y las localidades que sean más vulnerables.*

Palabras Clave: bienestar animal, CITES, mercado de mascotas exóticas, mercado de vida silvestre

Introduction

International trade in exotic pets is an important and increasing driver of biodiversity loss (Sodhi et al. 2004; Fernandes-Ferreira et al. 2012). In their systematic-style review, Baker et al. (2013) found that one-fifth of recent wildlife trade reports were driven by demand for pets or animals for use in entertainment. The pet trade has clear capacity to compromise the 5 freedoms required for good animal welfare (see <http://www.fawc.org.uk/freedoms.htm>) and welfare impacts in the related domains involving “behavioral or interactive restriction,” and “anxiety, fear, pain or distress” are most likely to be reported when animals are traded for live use (Baker et al. 2013).

We examined the current global state of the exotic pet trade through diverse sources of information to document its features, highlight knowledge gaps that limit effective regulation, and inform future action. By *exotic* we mean a species that does not have a history of domestication, as defined by Price (1984). Exotics are those without a long history of captivity and are likely to have been sourced directly or within a few generations from wild populations. *Pet* refers to an animal kept within a domestic setting, where its main purpose is for personal interest, entertainment, or companionship.

Factors Affecting the Exotic Pet Trade

Demand for exotic pets is not new; the collection of wild animals for human entertainment and companionship has been part of human culture since prehistory (Driscoll & Macdonald 2010). Podberscek et al. (2005) refer to a diverse range of companion animals in Ancient Greek and Roman culture. However, the novel factors of demand, infrastructure, and accessibility affect modern trade.

The human population more than doubled in the last century and continues to grow (UNFPA 2011). If per capita demand for pets remains the same, overall demand will increase without comparable growth in source animal populations (Dickman et al. 2007). To a collector, the rarity of a species can enhance its desirability and market value (Fernandes-Ferreira et al. 2012), known as the “anthropogenic Allee effect” (Courchamp et al. 2006), this market failure can result in extreme population suppression because profits are maintained despite greater costs in capturing target animals as they become rarer. In South America and East Asia, where pet keeping is popular (Alves et al. 2010; Kuhnén et al. 2012), increasing affluence (McNeely et al. 2009) is expanding the consumer community for exotic pets (Ding et al. 2008).

International travel and transport of goods are now commonplace, and they facilitate movement of wild animals through legal and illegal pathways (Dutton et al. 2013). New media have a strong influence on modern pet trade; Internet companies that source pets and increased access to information are driving demand for yet more novel pets. The global dissemination of wildlife films—even those with apparently pro-welfare messages such as “Finding Nemo” and “Rio” (featuring a clownfish [*Amphiprioninae*] and Blue Macaws [*Anodorhynchus hyacinthinus*], respectively)—coincide with peaks in demand for featured species (Yong et al. 2011). Fragmentation and new roads linked to logging allow easier access to wildlife, particularly in forested landscapes (Laurance et al. 2008).

International Pet Trade Legislation

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement which operates as a licensing system through which imports and exports of listed animals must be authorized by member states. Species are listed by the convention on one of 3 appendices depending on their conservation status and popularity in trade. The onus lies with member states to enact this framework within their own legislative system and to submit annual trade reports. Permits for trade may be granted if the state scientific authority advises a “nondetriment finding” that trade will not be a detriment to the survival of the species and that sufficient standards of animal welfare will be maintained in transit. Of course, political will, scientific integrity, and enforcement vary by country and taxa. In Indonesia, high-profile animals such as orangutans (*Pongo* sp.) receive greater attention from authorities than less charismatic species with a similar conservation status such as macaques (*Macaca* sp.) (Shepherd 2010). Traders may be unaware of, or fail to be influenced by, legislation; the costs to them of abiding by the law being greater than not (Fernandes-Ferreira et al. 2012) and penalties may be less than gains of the trade (Dutton et al. 2013). Those entrusted with enacting legislation also often lack the critical expertise needed to recognize species traded illegally.

Pet Sources

Exotic pets may be sourced directly from the wild, taken from the wild as eggs, born in captivity from wild parents, reared in captivity, or bred in captivity. Some exotic pet species are bred successfully in captivity (e.g., Chinese softshell turtle [*Pelodiscus sinensis*]) (Haitao et al. 2008),

whereas others are difficult or impossible to breed due to inadequate knowledge of their reproductive biology (Nogueira & Nogueira-Filho 2011), high levels of stress, or other impediments such as K-selected life histories (Mattioli et al. 2006). For these, the expense and inefficiency of captive breeding compared with wild capture (Exotic Pets 2012) deters the development of good breeding practice. Extrapolations from the capacity of some legitimate breeding facilities indicate that the volumes of allegedly captive-bred animals reported are implausible, raising the suspicion that some facilities serve as cover for illegal wild capture (Nijman & Shepherd 2009; Lyons & Natusch 2011).

Conservation and Animal Welfare

We identified 2 main motivations to study the exotic pet trade: conserving populations and ensuring the welfare of the individual. In addition, within the context of interdisciplinarity that characterizes modern conservation (Macdonald et al. 2007), we are mindful that this topic also embraces wider societal issues. For example, transporting pets creates an epizootiological risk (Macdonald & Laurenson 2006), can lead to exploitation of the rural poor by organized crime (Dutton et al. 2013), but also provides a significant income stream to marginalized rural communities (Roe et al. 2002).

The question that runs throughout wildlife trade debate is whether trade helps or hinders wildlife conservation. Sustainable exploitation of wild populations is theoretically possible, but the nature of international markets has perhaps decoupled feedback mechanisms that work to maintain sustainable resource use in a closed system. Hutton and Webb (2002) identify 2 contrasting hypotheses that determine how different actors perceive and value wildlife trade: that legal trade can be used to displace illegal trade and that legal trade will inevitably encourage illegal trade. The former is often proposed by economists as a market solution, whereas the latter is derived from a precautionary approach, that the structures for legal trade can provide increased and often uncontrollable opportunity for illegal and unregulated trade.

Captive breeding as a solution to the problem of wild extraction is patchy in its success, and where it is successful it rarely acts as an absolute alternative to wild-sourcing because demand remains for fresh stock from the wild to bolster breeding programs (Exotic Pets 2012). So wherever exotic pets are primarily sourced from, it is prudent to address the effects of removal from the wild on the viability of source populations. However, determining a sustainable harvest rate is not simple; accurate local data concerning demographic parameters and external factors affecting exploited populations are required to calculate a meaningful rate (e.g., harvest quota for long-tailed macaques [*Macaca fascicularis*], in Yogyakarta Special Province, Indonesia [Santosa et al. 2012]). There are

further difficulties in the implementation of sustainable harvest; traders compromise quotas through ignorance of their existence and movement of animals through small informal markets is problematic for enforcement (Shepherd 2010). Unsustainable harvest of wild animals for the pet trade has already led to population decline and collapse for many species. For example, the radiated tortoise (*Astrochelys radiata*) is critically endangered and has been predicted to be extinct within 45 years (Leuritz & Rioux Paquette 2008).

Animal welfare is compromised to some extent at all stages of the exotic pet trade. A certain set of challenges are specific to animals taken directly from the wild. Bird capture methods include painting a sticky resin to trees that damages feathers and limbs (Fernandes-Ferreira et al. 2012). Primate adults are killed so their young can be taken (Kabasawa 2009) or primate young are taken as a by-product of the bushmeat trade. Adjustment to domestic life includes radical changes in behavior and diet. Bird traders in Brazil acclimate wild-caught birds to the type of dry food available worldwide, which is often inappropriate for the species or age class (Engelbreton 2006; Fernandes-Ferreira et al. 2012). Some argue that all exotic pets are wild animals, and it is unethical to keep them in captivity (PETA 2013). However, there is a scale of suitability dependent on the temperament of the animal and the complexity of its needs that is linked to its level of specialization in the wild. Some species at the unsuitable extreme of this scale are referred to as cut flowers. For example, the slow loris (*Nycticebus* sp.) is sold at a relatively low price because it does not survive long in captivity following removal of its teeth to prevent a toxic bite (Shepherd et al. 2004; Shepherd 2010).

Another set of stressors are specific to animals bred in captivity (e.g., bone disease caused by premature physical activity and deficient diet are associated with infant parrots raised by hand to increase their tractability) (Engelbreton 2006). Further stressors are relevant to all animals in the pet trade irrespective of their provenance. Animals are packed in large numbers (Regueira & Bernard 2012) and mortality is high during transit; conservative estimates include ratios of 3 animals dead for every one traded alive to the consumer (Redford 1992). Husbandry of nondomesticated animals is often difficult and expensive (RSPCA 2012) and thus the practicalities inevitably compromise many aspects of behavior. Cages are small relative to species' needs (Ceballos-Mago & Chivers 2010), for practical reasons it is unrealistic to keep flocking animals in natural-sized groups (Alves et al. 2010), and animals are exposed to humans and other multispecies assemblages resulting in aggressive and stressed behaviors (Regueira & Bernard 2012).

Research Questions

We reviewed the literature and CITES reports to examine the current state of the international exotic pet trade with

	Legal	Illegal
Threatened	A	B
Nonthreatened	C	

Figure 1. Logical distribution of exotic pet trade scenarios. International trade is either legal or illegal (CITES and other international law), and species are threatened or nonthreatened (IUCN classification).

respect to the 3 taxonomic classes of terrestrial vertebrates principally involved: birds, reptiles, and mammals (Baker et al. 2013). We asked which taxonomic groups are most exploited for the pet trade, what is the conservation and legislative status of these species, what are the major international trade routes, and what are the biases of the different sources in terms of research effort and coverage?

Methods

We gathered data from 3 sources: scientific literature, gray literature (reports from relevant expert NGOs), and trade records from the annual reports of CITES member states. These sources enabled us to assess trends on an international scale and to sample from all possible trade scenarios (legal and illegal trade and threatened and nonthreatened species; Fig. 1). Certain sources are biased toward certain trade scenarios. Legal trade in threatened species (scenario A) is most likely reported through the CITES network while one would expect greater emphasis on all scenarios involving threatened species both legal and illegal (scenarios A and B) from the literature due to scientific concern. Legal trade in nonthreatened species (scenario C) is likely given least attention; however, the literature includes indiscriminate surveys from open pet markets that sample this scenario. But this is less common in western countries, where animals are rarely sold in this way. The final scenario, illegal trade in nonthreatened species should not be theoretically possible according to CITES because listings are based on level of threat.

Literature Search Strategy and Data Extraction

Predetermined criteria were used to search on-line library databases (Web of Knowledge, Scopus, Zoological Records, CAB Abstracts, and Cambridge Scientific Abstracts) for scientific papers written in English, published between 1 January 2006 and 4 May 2012, and containing the terms *wildlife trade* and *pet trade*. We searched all available fields including title, abstract, article, topic, and full text. We downloaded full citation details, abstracts, and URLs wherever possible, and all items were screened for eligibility against the following review criteria: full text can be accessed and reference is made to trade of an exotic bird, mammal, or reptile as a pet.

We searched the Web sites of international NGOs relevant to the trade of exotic species (Supporting Information). Where a publication list was available, we downloaded all reports published from 1 January 2006 to 12 July 2012 that fulfilled the query *pet trade* found through the search facility if present, or we took the first 10 downloadable reports from the publications page if a search could not be made. A report was eligible if it made reference to trade of an exotic bird, mammal, or reptile.

Each selected article (paper or report) was given an identification code, citation details were noted, and main theme and references to welfare were recorded. Further data were taken from articles that referred specifically to capture, trading, or ownership of pets in such a way that records of species names and trade routes could be extracted (e.g., surveys of bird markets in Jakarta) and cross referenced with other sources (CITES 2012; IUCN 2012) to compile information on taxonomic rank, conservation status, legal protection, and route of trade. Multiple records were extracted from articles that made multiple references to species in trade. These data were used to assess representation of different taxa and to identify main trade routes.

When source countries were not recorded, we researched the native range of the species using the International Union for Conservation of Nature (IUCN) and Bird Life International Web sites and assumed harvest from wild populations. The consensus from the literature is that within the diversity of species traded as pets, few are successfully bred beyond 1 or 2 generations without wild-caught input, due to complex dietary requirements and inbreeding. Thus, although our assumption of wild provenance may be imperfect, it provides a plausible indication of the flow of wild-caught species.

CITES Search Strategy

States party to CITES are required to submit annual reports of international trade in listed species which are made available on the UNEP-WCMC CITES trade database (www.unep-wcmc-apps.org/citestrade/trade).

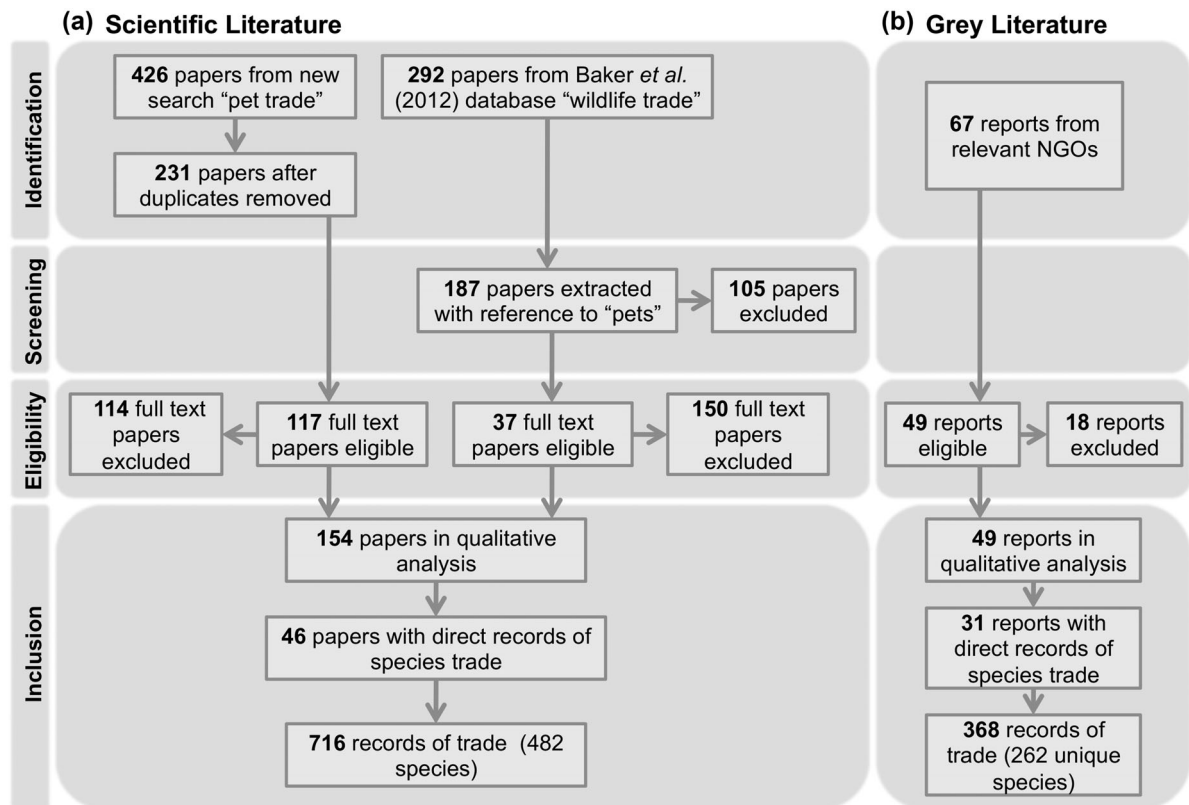


Figure 2. The search strategy detailing identification, screening, eligibility, and inclusion of research articles from the scientific literature and the gray literature (publications from expert organizations) in a systematic review of the exotic pet trade.

cfm). We queried the database for all records of trade in live animals for personal use (CITES purpose code P) to best approximate trade in exotic pets recorded through CITES (however this may give a conservative estimate because detailed use of shipments were not available to differentiate between pets and other uses under the commercial trade code). Other CITES purpose codes accounted for scientific research, zoo, and circus trades (CITES 2004). We downloaded 3 different outputs: comparative tabulation report, net (re)export report, and net import report for the years 2006–2010 inclusive (2010 being the most recent complete year), and we filtered these for records of birds, mammals, and reptiles. We coded each record to represent whether trade had the potential to impact wild source populations according to the source information provided: captive-bred, animals bred in captivity (at least F2 generation) for commercial and noncommercial reasons including ranches; wild-caught, animals taken from the wild directly or born in captivity from wild-caught parents (F1 generation); other, animals of other declared origin such as a customs seizure or a preconvention specimen; unknown, animals of undeclared origin. When import and export reports disagreed, we used import information to maintain consistency.

We used these data to identify the most active trading continents for different taxa of legally traded animals and

to assess the representation of different taxa within and the contribution of different sources to the international pet trade. We used descriptive statistics and chi-squared analysis to compare observed frequencies of species and threat status with that expected under a scenario of random sampling from all described and categorized species.

Results

Summary of Search Results

There were 154 papers and 49 reports included in the review (Supporting Information). Among these, were 716 records of trade representing 482 different species from 46 papers and 368 records of trade representing 262 species from 31 reports (Fig. 2). From the CITES trade search, we extracted 2651 records of net export (465 species) and 2143 records of net import (558 species).

The mean rate of publication on the exotic pet trade between 2006 and 2011 was 25 papers and 6 reports per annum. A fifth of the papers ($n = 154$) and just over half of the reports ($n = 49$) focused on harvest or trade directly, whereas a further third of the papers reported on the ecology and conservation of species affected by trade. The rest consisted of comment and campaigns or

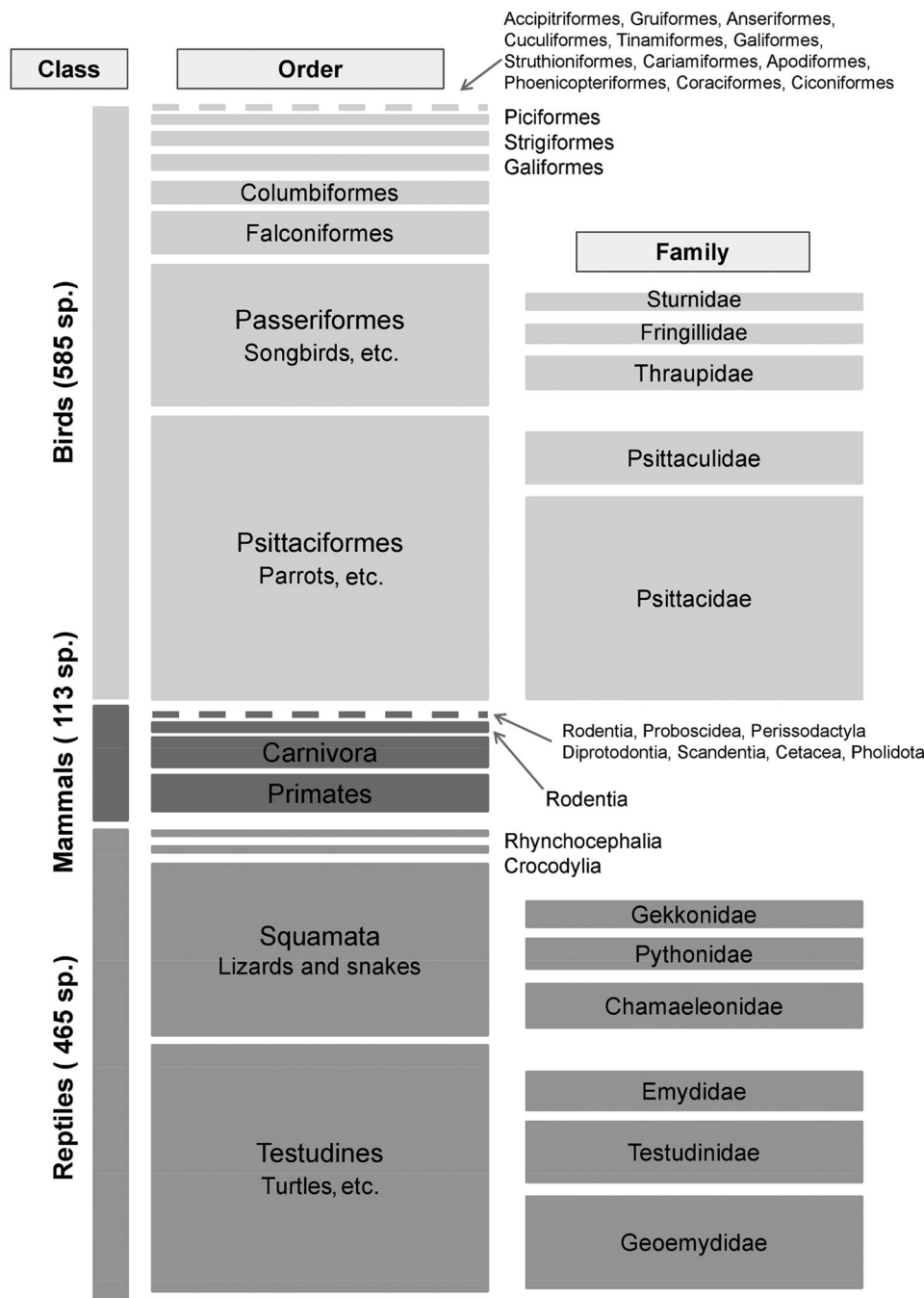


Figure 3. The proportion of species recorded in the pet trade among different taxonomic groups. This schematic shows that birds, mammals, and reptiles have not been represented equally from reports of the pet trade ($\chi^2 = 310.5$, $df = 2$, $p < 2.2e - 16$). It was compiled using all available sources: scientific literature, gray literature, and CITES trade database. Bars are scaled by height to represent the number of species, and only the most diverse families are shown.

were related to identification, zoonoses, or behavior of species involved in trade. Twenty-three percent of the papers and 41% of the reports commented on the welfare or health of the species being traded.

Most Exploited Taxa

On the basis of a species list compiled from all sources, species richness of the taxonomic classes reported in the exotic pet trade did not represent a random selection of all described species (IUCN 2012) ($\chi^2 = 343.7$,

$df = 2$, $p < 0.001$). Birds were the most species-rich class reported in trade (585 sp.) and were overrepresented relative to their described diversity. Reptiles (485 sp.) were the second most species-rich class reported in trade and were followed by mammals (113 sp.) (Fig 3).

Parrots (*Psittaciformes*), song birds (*Passeriformes*), and falcons (*Falconiformes*) were the most common avian orders in reported trade. Parrots were reported in the pet trade 14 times more often than if selection among avian orders was random, indicating a strong bias for them in this context. The most diverse reptilian orders

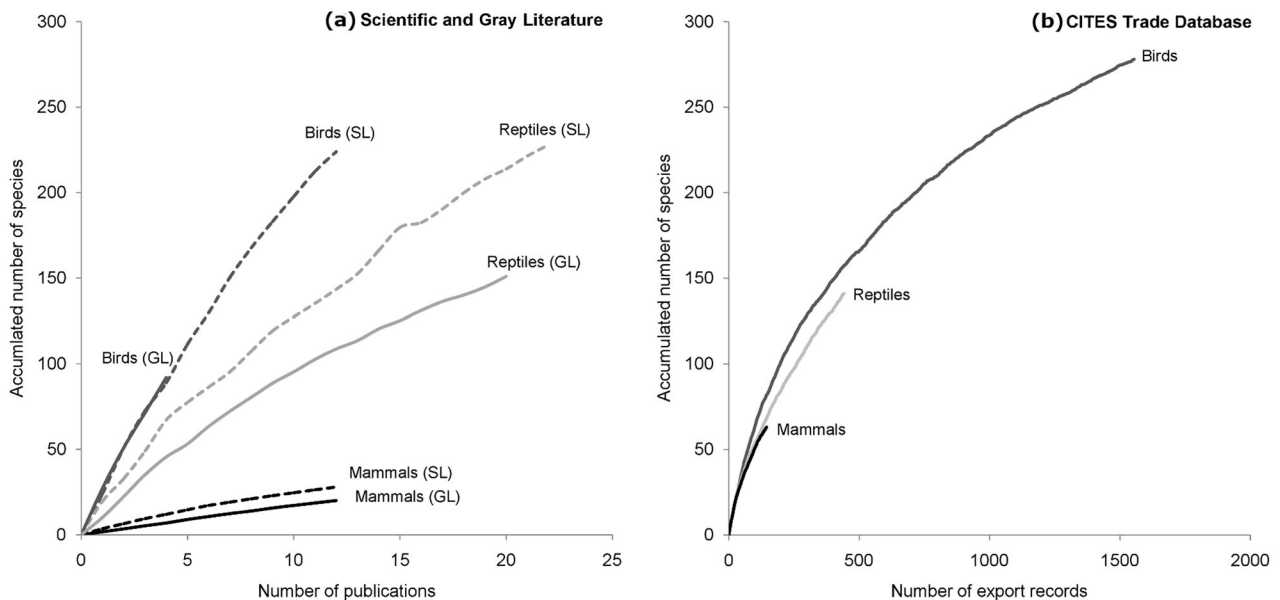


Figure 4. Cumulative number of species (per class) involved in the international exotic pet trade by (a) research or report effort from scientific (SL) and gray literature (GL) (average of 100 randomizations) and (b) exports from the CITES Trade Database. Publications from the literature could report on multiple species, whereas each CITES export record reported on a single species.

reported were turtles (*Testudines*) and lizards and snakes (*Squamata*). Turtles were reported in the pet trade 17 times more often than if selection was random among reptilian orders, and lizards and snakes were reported half as often. Mammal species were half as likely to be recorded in the pet trade than if selection was random and consisted mostly of primates and carnivores.

To understand the contribution of each of the 3 sources used toward the taxonomic pattern described earlier, we assessed species-richness accumulation against reporting effort (Fig. 4). For the scientific and gray literature, number of articles was not equal among the taxonomic classes ($\chi^2 = 13.0$, $df = 2$, $p < 0.01$). Most publications were on reptiles (22 papers and 20 reports), followed by publications on mammals (12 papers and 12 reports) and then birds (12 papers and 4 reports). There was no sign of an asymptote for either birds or reptiles, indicating that research effort has not been sufficient to characterize trade fully.

Records from the CITES trade database confirmed the gross taxonomic pattern above; bird and reptile species were recorded more often in trade than were mammals. However, there were fewer records of reptile trade than of bird trade, and this smaller sample size doubtless explains part of the difference in diversity of reptile and bird species reported. Fewer reptiles are listed within the CITES appendices, so trade is not reported to the secretariat, and reptiles are easier than birds or mammals to smuggle on illegal and therefore unreported pathways. For example, customs officials in the United Kingdom have been alerted to tourists transporting small turtles in

their pockets on flights from holiday destinations (RSPCA 2001).

Twice as many species of mammal were recorded in the CITES records than from the literature. This may indicate a bias against expert research into mammalian exotic pets or the difficulty in reporting on the trade as mammals tend to be sold through different forums: most birds and reptiles were recorded in large numbers at open pet markets (66% bird records and 78% reptile records from market surveys), whereas mammals tended to be traded in smaller numbers by request (only 43% mammal records from market surveys, otherwise observed through household interviews and seizure records).

Conservation and Legislative Status of Species in the Pet Trade

Of the species currently assessed for the IUCN Red List (IUCN 2012) birds, mammals, and reptiles have not been represented equally among the categories of threat ($\chi^2 = 2096$, $df = 10$, $p < 2.2e-16$); half of all named reptile species are either unclassified or data deficient. This gives some insight when analyzing the number of species associated with the exotic pet trade from the literature records that are classified in each red-list category (Fig. 5). Reptile and mammal species recorded in the exotic pet trade were more likely to be classified as threatened (critically endangered, endangered, or vulnerable) than otherwise. A mammal is almost 3 times as likely to be threatened if reported in the pet trade (56% species in pet trade threatened vs. 21% generally), and a

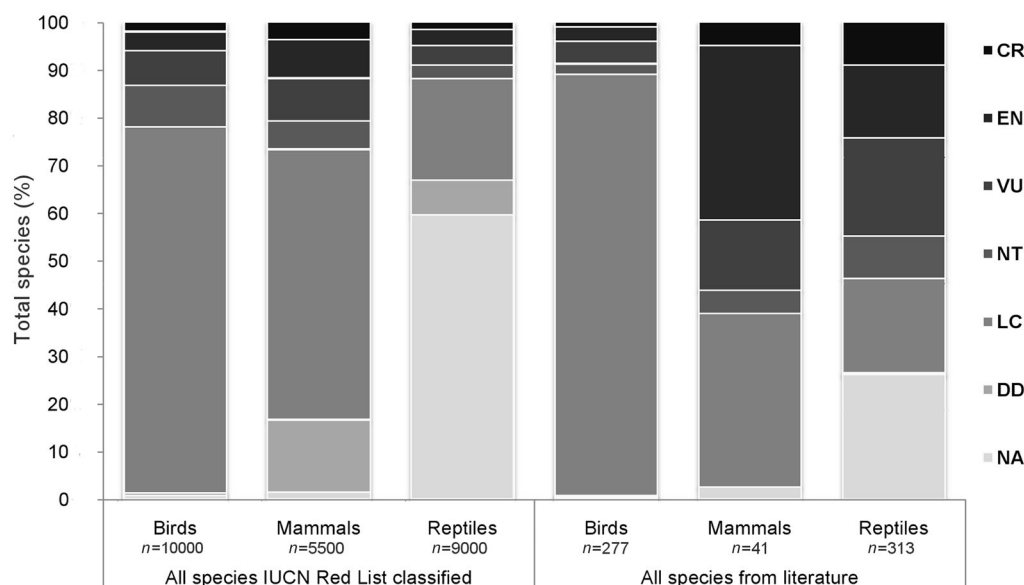


Figure 5. Comparison between the proportion of species listed in the IUCN Red List categories and those species reported in the exotic pet trade in the literature (IUCN Red List assessment categories: CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern; DD, data deficient; NA, not yet assessed). Bird, mammal, and reptile species were not represented equally among the IUCN Red List categories (Fig. 6; $\chi^2 = 2096$, $df = 10$, $p < 2.2e-16$). Mammals and reptiles were more likely to be threatened if they were involved in the pet trade than in general, whereas birds were less likely. Source: IUCN 2012 and trade records extracted from review literature.

reptile is 5 times as likely to be threatened (45% species in pet trade threatened vs. 9% generally) than a species of that taxonomic class in general. In contrast, bird species reported in the pet trade were 1.5 times less likely to be threatened than species of that class in general (9% species in pet trade threatened vs. 13% generally). The Javanese Myna (*Acridotheres javanicus*) and the serrated hinge-backed tortoise (*Kinixy serosa*), found in markets in Taiwan and China, respectively, were the only traded species we found classified as data deficient.

Major Patterns in International Trade

From the CITES records extracted for review, we found that birds, mammals, and reptiles were not traded in equal numbers between 2006 and 2012 ($\chi^2 = 88,015$, $df = 2$, $p < 0.001$). More individual birds were reported in transit ($n = 56,792$) than mammals ($n = 1226$) or reptiles ($n = 6310$). Using the CITES trade comparative tabulation report, we assessed the number of individuals in each class recorded therein as traded under each Appendix rating. Over 40% of all birds and 30% of all mammals traded were Appendix I listed species, which amounted to 24,634 animals over the 4 years. This included the removal of 88 individual wild-caught Yellow-naped Parrots (*Amazona auropalliata*) from Central and South America to the United States and Canada and the transportation of 48 captive-bred cheetahs (*Acinonyx jubatus*) from Africa to Europe and the Middle East. There were no details

available as to the exceptional circumstances that permitted these trades. Birds (23%) and reptiles (10%) were more likely than mammals (0%) to have been reported as taken from the wild or to be first generation from wild parents in our analysis.

Using the net export and import reports from the trade database, we established that there were different patterns in trade between continents in CITES-listed species according to taxonomic class (Fig. 6). Europe consistently exported the greatest number of birds, yet did not feature as a large importer due to the ban on bird trade into the European Union (RSPCA 2007). Instead the Middle East and Central and South America were the main importers for this period with, on one occasion in 2006, 753 falcons (*Falco hybrid*) transported from Germany to the United Arab Emirates under one permit. Africa has been the largest (re)exporter of mammals, followed by North America and the Middle East, and it was the latter that imported the largest numbers of mammals, followed by Europe and Africa. One hundred forty-eight individual captive-bred, Appendix I listed, Arabian oryx (*Oryx leucoryx*) were traded within the Middle East or from the Middle East to Africa, Europe, and Asia over the 4 years. In 2008, there was a peak in reptile exports from North America, but recent trade out of Europe has surpassed this. Europe also imported the largest number of reptiles during this time, followed by the Middle East.

Using the CITES comparative tabulation report—detailing 65,846 individual mammals, birds, and reptiles

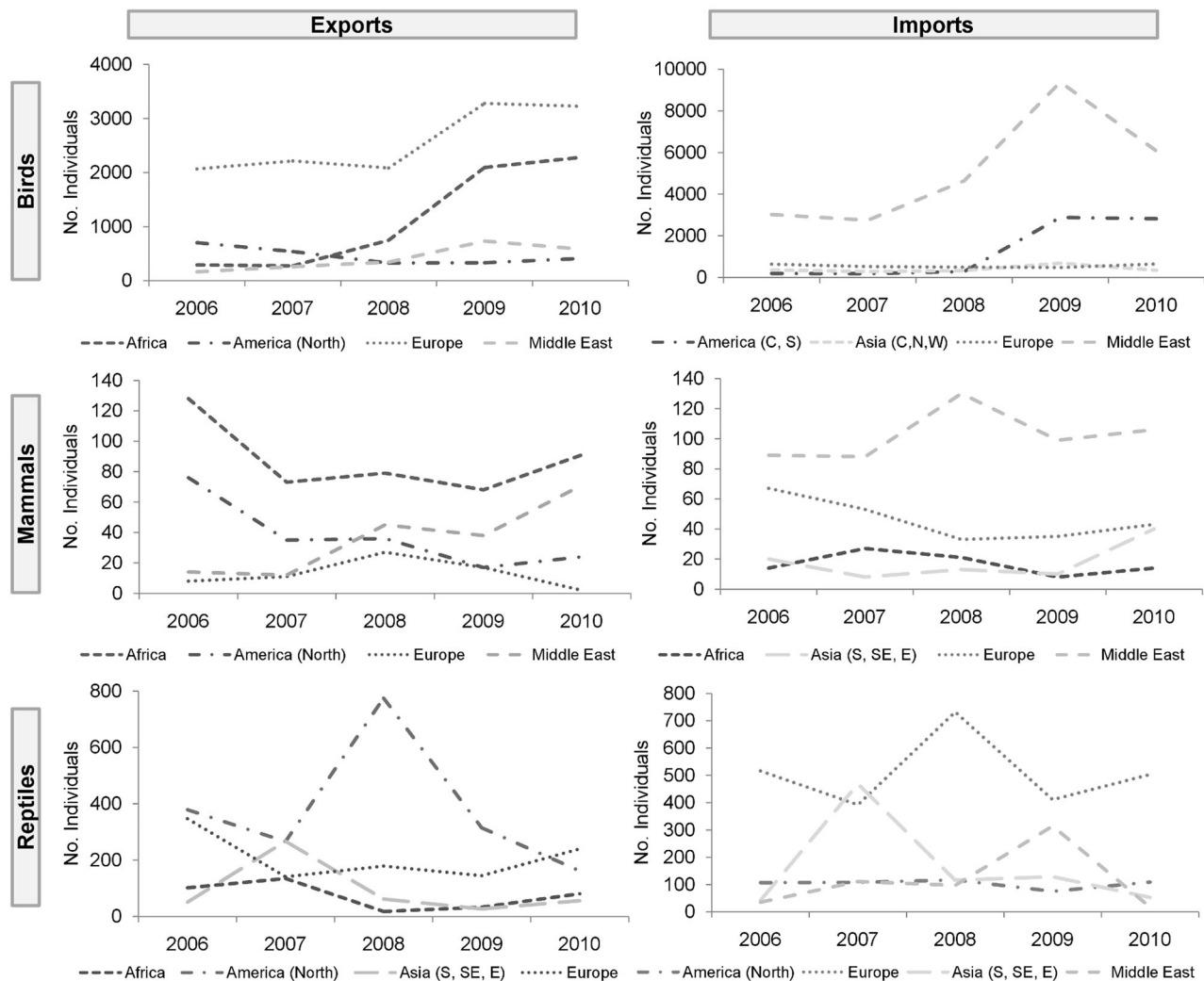


Figure 6. Trends in net export and import of birds, mammals, and reptiles between 2006 and 2010 by continent. Source: CITES Trade Database.

traded internationally between 2006 and 2010, we found major trade routes for CITES-listed species for each taxonomic class using the declared state of origin over exporting country if available and different (Fig. 7a).

From the records of trade extracted from the scientific and gray literature, 1065 records either gave both source and sink country or gave the sink country, and we identified the native range of the species as the source. Using the number of records, rather than numbers of individuals traded (which were not available), we constructed a comparable world map to show the location and magnitude of the main trade routes reported by the scientific and expert community (Fig. 7b).

Neither map represents a perfect picture of trade due to incomplete coverage of information from the data sources; however, the following key points can usefully be made when comparing these 2 representations of the exotic pet trade.

The main avian trade route recorded through CITES consisted mostly of parrots from Africa (mainly South Africa) to the Middle East (307 records of trade, 5908 individuals) and of falcons from Europe to the Middle East (647 records of trade, 17,755 individuals) to feed demand from Arab falconers (MEFRG 2013). The African Grey Parrot (*Psittacus erithacus*) was most frequently exported alongside other African natives such as lovebirds, parakeets, parrots, and captive-bred Amazonian parrots and macaws, American parakeets, and Asian and Australasian cockatoos. African Grey Parrot populations are in decline throughout Central and West Africa due to trapping for the pet trade. Estimated exports to the Middle East, Europe, and North America (prior to the bird import bans in the latter 2) exceeded quotas (BirdLife International 2013). Of all CITES-listed birds imported into Central and South American countries, 85% were from other countries within that continent and consisted mainly of parrots. In fact, wild-caught Monk Parakeets (*Myiopsitta*

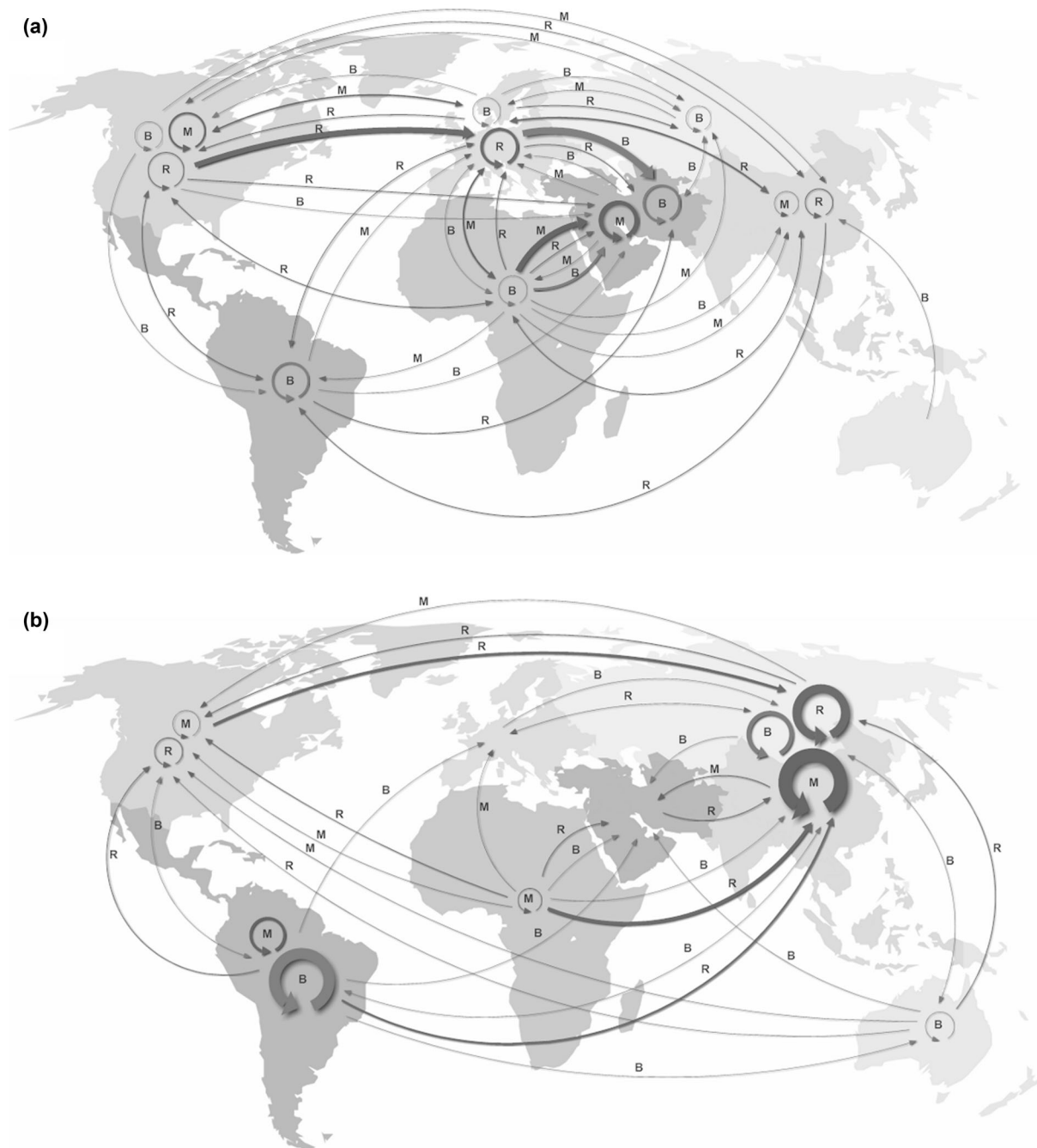


Figure 7. Inter- and intracontinental trade routes of birds (B), mammals (M), and reptiles (R) as pets: (a) CITES-listed species traded legally between countries party to CITES (arrow width scaled to represent number of individuals traded between 2006 and 2010) and (b) scientific and expert reports of species traded domestically and internationally (arrow width scaled to represent number of trade reports between 2006 and 2012 and includes legal and illegal movement of CITES and non CITES listed species).

monachus) accounted for 97% of all reported trade in parrots within South America from just 3 shipments that totaled 5400 individuals transported from Uruguay to Mexico between 2009 and 2010. Movement out of the Americas constituted most of the wild-caught avian trade. In comparison, evidence from the literature highlighted

the major trade chain within South America but missed the trade into Europe and the Middle East due to lack of published research in these areas. Substantial trade within Asia of non-CITES-listed or illegally traded species was identified from the literature records, mostly of wild-caught individuals through informal networks.

The majority of mammal trade reported to CITES in our analysis was from Africa to the Middle East (mostly felids and ungulates destined for private collections), followed by reciprocal trade between Europe and Africa and between Europe and North America and intracontinental trade in the Middle East and North America. All CITES mammal records we accessed declared the animals as captive bred on export, so this should not represent wild extraction. However, high-profile cases, such as the Taiping Four, where young wild-caught gorillas from Cameroon were exported in a trafficking scam through Ibadan Zoo in Nigeria to Malaysia, show that cases may be reported inaccurately (McGreal 2004). Almost all the trade chains identified through CITES were underrepresented in the scientific and expert reporting, especially those involving North America and Europe. In addition to that listed above, major illegal or non-CITES intracontinental trade was reported from the literature within Asia and South America. This trade consisted of wild-caught mammals such as civets (*Viverridae*) (Shepherd 2008), slow loris (*Nycticebus* sp.) (Nekaris et al. 2010), and capuchins (*Cebus* sp.) (Ceballos-Mago et al. 2010), all destined for private homes as pets.

The most common trade route for CITES-listed reptiles was from North America to Europe, followed by reciprocal trade between Europe and Southeast Asia, and substantial intracontinental trade within Europe. Wild-caught individuals featured among all these routes. Europe's role in this global pattern of trade was once again not apparent in the literature, which instead focused on movement of reptiles from South America, North America, and Africa to Asia and informal trade between and within Asian countries. Because much of the scientific reporting was based on market surveys, information regarding the provenance of the animals (wild-caught vs. captive bred) was not usually available.

Discussion

We established a picture of recent global trade in exotic pets on the basis of the most comprehensive information available. CITES trade data showed international patterns of movement in CITES-listed species and helped to identify the continents and countries that fuel demand for exotic pets, whereas the scientific and gray literature allowed us to assess conservation and research effort regarding the exotic pet trade across the globe and to sample the informal and illegal trade in CITES and non-CITES-listed species. The biases inherent in this context include the difficulty in characterizing the frequency of illegal, nonrecorded trade in CITES-listed species and of separating the market into legal versus illegal and captive-bred versus wild-caught animals. The legality of trade does not guarantee its sustainability. By default, trade is legal unless a motion is successfully brought

before CITES to demonstrate negative impacts. Therefore, one can assume that there is legal trade that is damaging wild populations that remains unregulated because of outdated conservation assessments or lack of motivation to bring the case before CITES.

Distribution of Trade and Research Effort

As expected, historical hubs—Southeast Asia and South America—featured heavily in both sourcing the exotic pet trade and fueling demand. We also highlight the role of the Middle East in the exotic pet market. Our results show this region has become a major driver of trade in all taxa, yet little scientific work has been dedicated to this topic in this region and so few of the reasons for this or the purpose of the trade shipments are understood. In a similar vein, we highlight the case of Africa. From the paucity of reports originating from this continent, Africa appears to be a source rather than a sink for exotic pets for the global market (based on reports of native African animals occurring elsewhere), and there is no evidence of substantial trade among African nations. Where demand for wild-caught pets has been documented within Africa, it has historically been attributed to the expatriate community (e.g., chimpanzees [*Pan* sp.] kept as pets in Sierra Leone [Kabasawa 2009]). However, the recent description of Lesula (*Cercopithecus lomamiensis* sp. nov.) from the Congo basin, occurred because the monkey was found being kept as a pet in a forest village (Hart et al. 2012).

Conservation of Wild Populations

As expected, the majority of animals permitted to travel through CITES for personal use were declared captive bred. It was perhaps more surprising that as many as 20% of birds and 10% of reptiles were declared wild-caught or of wild parents, including some Appendix I listed species (e.g., the Monk Parakeet). Evidence from the literature pointed toward common informal trade in wild-caught animals, often within country. Mammals and reptiles reported in the exotic pet trade literature were more likely to be threatened than expected from a random sample of all those assessed by the IUCN. Extraction for the pet trade could be driving decline of these species, although we must also consider that more research effort is devoted to threatened animals and that consumers may prefer rare species (as shown in the context of African wildlife trophies [Johnson et al. 2010]). However, many of the articles reporting on reptile trade were indiscriminate (such as market reports), so this pattern of threat cannot be dismissed simply as a bias toward threatened species. In contrast, birds reported in the exotic pet trade were less likely to be threatened than expected. Interpretations could include threatened bird species not being popular pets, successful legislation regulating avian trade,

or species at lower risk being traded due to indiscriminate capture techniques.

To qualify for a red-list classification the threats to a species must be identified, and we have observed from the IUCN Red List that of the 2 avian orders most often traded as pets, 72 of 103 parrot species and 69 of 109 songbirds targeted by intentional hunting are categorized as threatened (IUCN 2012). In addition, of the 5501 mammal species assessed by the IUCN, 916 have been listed with the main threat as “intentional use of the species,” which—while including uses other than as pets—serves as a warning of the effects of extraction on population viability (IUCN 2012). Although they are among the animals most often reported in live trade (Baker et al. 2013), the scientific community has comparatively neglected reptiles for conservation assessment. The majority of described species have not been assessed for the IUCN Red List and a further percentage is classified as data deficient. Until this is rectified, the CITES appendices (which are based on threat levels) will fail to protect some threatened species.

It is imperative for monitoring and accountability that the annual reports of member states to CITES maintain or improve their reliability. There are inconsistencies between export and import records within the database, such as conflicting purpose and source codes. Especially where animals are being traded for “personal use,” we recommend that official records be kept regarding the destination of shipments and explanations of how the nondetriment finding has been met. Within-country awareness of quotas and the legality of wildlife-capture must be strengthened so that traders are not ignorantly breaking the law. Officials should be better educated in species identification of high-priority species, and enforcement must be applied uniformly despite the rural location, informality of trade, or charisma of the species. Population viability analyses to assess the impact of extraction on wild populations would enable appropriate corrective measures to be identified for those species in trade declared as wild-sourced.

Welfare of the Individual

The case that the welfare of animals within the pet trade is compromised has been established (Baker et al. 2013), and the plight of the individual, from which wild and captive populations are constituted, has certain relevance. Conservation and welfare are often considered 2 separate world views in science, although we think they are more fruitfully thought of as different but often overlapping emphases, a position recently encouraged by the work of Dubois and Fraser (2013), who reported on the high level of agreement between those people primarily animal welfare orientated with those conservation orientated. For the issue of the exotic pet trade, there is perhaps unusually straightforward congruence between conser-

vation and welfare. For example, convincing consumers of the compromised welfare of wild animals in captivity or the epizootical risk they pose could result in reduced demand, an outcome that could aid conservation of wild populations and reduce the number of individuals whose welfare is affected. Greater monitoring of breeding facilities to ensure good conditions for animal welfare would help elucidate their activity and ensure they are not acting as cover for wild-caught trade.

Results of our systematic review confirmed that exotic birds, mammals, and reptiles are traded as pets in great abundance and diversity and that both as sink and source this trade exists throughout the world. Many of the species traded as pets are threatened and that almost always there are clear reasons to believe that welfare of individuals is compromised. Because our review deals largely with legal trade, for which even the known unknowns gravely hamper interpretation, it is obvious from literature reports that the unknown unknowns of illegal trade in exotic pets is of even greater concern. Although the impact of being traded on the welfare of individual pets is often at least somewhat visible, the downstream impact on the viability of wild populations is generally unknown. Those principally motivated by the promotion of animal welfare or by the conservation of wild populations, should share concern for the knowledge gaps we have highlighted, and the risks to which species traded as exotic pets are exposed.

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Supporting Information

Supporting Information regarding the papers (Appendix S1) and reports (Appendix S2) from the systematic review are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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