ECOLOGY

Reducing the Risks of the Wildlife Trade

Importation of wildlife into the United States, most with scant identification, brings an increased threat of disease and introduction of invasive species.

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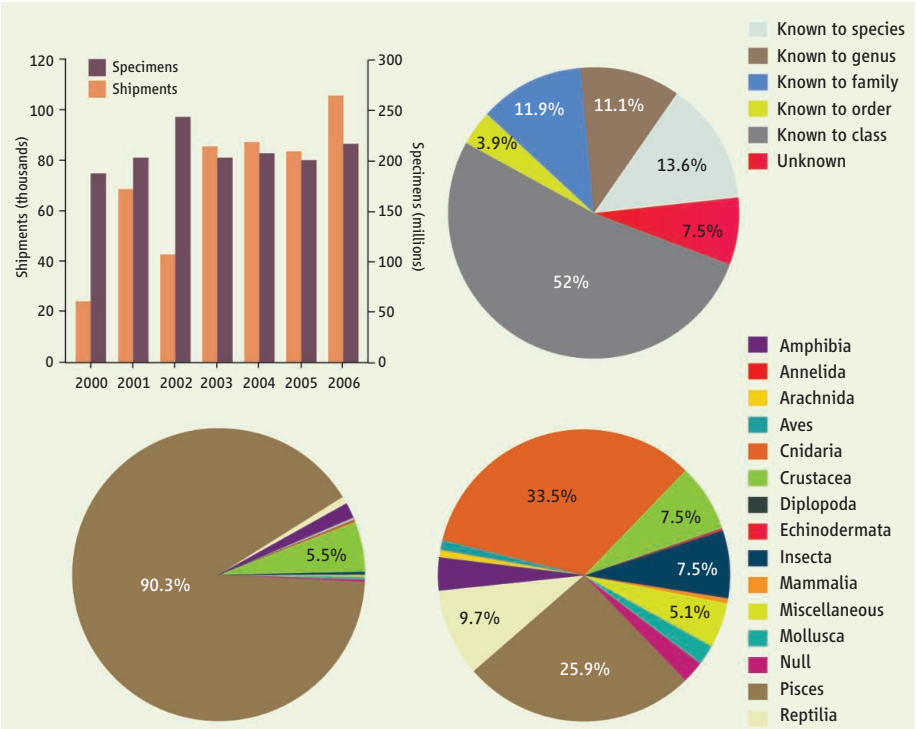
The magnitude of the international wildlife trade is immense, with estimates of billions of live animals and animal products traded globally each year (*1*, *2*). This trade has facilitated the introduction of species to new regions, where they compete with native species for resources, alter ecosystems, damage infrastructure, and destroy crops (*1*, *3*). It has also led to the introduction of pathogens that threaten public health, agricultural production, and biodiversity (*1*, *4*).

The 2003 outbreak of monkeypox virus in the United States illustrates the public health risks associated with live wildlife importation. Human infections resulted from contact with pet prairie dogs infected with monkeypox by African rodents imported for the pet trade (*5*–*7*). The monkeypox outbreak resulted in 72 human cases (*8*). The Centers for Disease Control and Prevention (CDC) and Food and Drug Administration issued regulations that, by November 2003, restricted both domestic trade in, and importation of, African rodents.

Nearly all government initiatives to regulate live wildlife imports have been reactive, focusing on detecting and preventing the spread of nonnative species already established (*9*) or initiated as an urgent response to an emerging public health issue (*10*). Current regulations are inadequate to accurately assess the diversity of wildlife imported or the risk they pose as invasive species or hosts of harmful pathogens. We obtained and analyzed all Law Enforcement Management Information System (LEMIS) shipment records gathered by the U.S. Fish and Wildlife Service (USFWS) for live wildlife imports and exports for the period 2000–06 (*11*). Whereas shipment data allow us to quantify the origin, source (wild versus captive), purpose, and diversity of taxonomic groups in the U.S. wildlife trade (*11*), the number of individuals in each shipment reveals the extraordinary magnitude of wildlife traded by the country. Over half a million shipments of wildlife containing >1.48 billion live animals have been imported by the United States since 2000 (see figure, top left). The number of shipments has increased significantly over this time, although the number of individuals shipped has not. With each shipment representing a potentially different origin, this suggests a growing threat. The majority (92%) of imports were designated for commercial purposes, largely the pet trade. Nearly 80% of shipments contained animals from wild populations, the majority of which have no mandatory testing for pathogens before or after shipment. Over 69% of live animal imports originated in Southeast Asia, which is considered a hotspot for emerging zoonotic diseases (*12*) (table S1). Cnidarians (e.g., coral) and fish, respectively, made up the greatest proportion of imported shipments and individual animals, although all major taxonomic groups were imported (see figure, bottom).

Despite mandated labeling of imported animals to species (50 Code of Federal Regulations 14) (*13*), the majority of shipment records did not contain the appropriate level of taxonomic information (see figure, top right), and almost one-third (31.1%) of imported shipments were identified with commonly used labels such as "marine fish," "live invertebrate," or "non-CITES" (that is, not subject to the Convention on International Trade in Endangered Species of Wild Fauna and Flora



Imported wildlife. (**Top, left**) Numbers of shipments and individual live wildlife specimens imported into the United States, for the period 2000–06 (*11*). Annual shipments have increased significantly over the period of the study ($R^2 = 0.76$, $F_{1,5} = 16.216$, $P = 0.010$). (**Top, right**) Percentage of live wildlife shipments imported for the period 2000–06 that were identified to a given taxonomic level. (**Bottom, left and right**) Percentage of live animal specimens (left) and shipments (right) depicted by taxonomic class or phylum, imported into the United States for the period 2000–06. LEMIS records place marine and freshwater fishes under the label "Pisces." Null refers to a shipment with no taxonomic information.

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or CITES). USFWS is charged with record-keeping of live wildlife imports at U.S. ports of entry [Endangered Species Act, 16 USC 1538(e)]. Port officers have the authority to detain or refuse shipments if the required documentation is missing or incomplete. The poor reporting of taxonomic status we find in the LEMIS database suggests a need to tighten protocols and makes it impossible to fully assess the biological diversity of wildlife entering the United States.

There is currently no coordinated national strategy, legislative authority, or funding devoted to oversight of the live wildlife trade. Scientific risk analysis of imported taxa, at the level of genus or species, would provide a considerable advance in assessing the threat that imported wildlife pose as invasive species or pathogen reservoirs. However, this is impossible given the current state of record-keeping. Correcting this problem would be a major first step toward risk analysis and reduction.

Risk analysis, as defined by the Convention on Biological Diversity (CBD), involves assessing the consequences of introduction, the likelihood of establishment of nonnative species, and the identification of measures to reduce or manage these risks, taking into account socioeconomic and cultural considerations (*14*). Effective risk analysis would require participation from all stakeholders, including the pet industry, and would need to be quantitative, to incorporate recently published data, and to include cost-benefit analyses of the economic and social benefits of wildlife ownership and trade. Findings could be used to rank threat levels for imported taxa and to prioritize those requiring more research or regulation, such as an importation ban.

Risk analysis based on the CBD definition would add balance to the Nonnative Wildlife Invasion Prevention Act (H.R. 669), the most recent proposal to improve U.S. regulation of wildlife importation. In its current form, H.R. 669 does not consider the economic benefits of wildlife trade. We argue that it should. H.R. 669 requires evaluation of the threat imported wildlife species pose as invasive species or carriers of known pathogens before importation. It proposes creation of lists of species "approved" or "unapproved" for import. Although the Act recognizes that there are species for which adequate scientific and commercial evidence is not yet available to make an evaluation of import risk, it does not stipulate how such species should be handled. For these species, we propose that H.R 669 should require their temporary placement on a "gray list." These gray-listed species should receive priority funding for risk analysis. It is currently impossible to know the proportion of species that would be on such a gray list. Until we begin evaluating the species proposed for import, it will not be clear which have adequate information for risk analysis and which do not.

Realistically, scientific information on the environmental, health, and economic impacts of many species in the trade is likely to be minimal. To support fair commerce we propose that, until scientific findings are released, gray-listed species that have been previously imported should be provisionally approved, whereas newly proposed species should be restricted. This would enable a flexible approach to the management of these species as additional information is collected.

H.R. 669 could be used immediately to deal with many traded species that have been fully researched by the scientific community. For example, some imported amphibians are reservoirs of a fungus (*Batrachochytrium dendrobatidis*) that causes chytridiomycosis, a lethal disease to many amphibians, and the cause of recent extinctions (*15*). There is excellent science identifying amphibian species that are likely carriers (*16*), which could be used to conduct adequate risk analysis.

To further reduce the risk of pathogen introduction via the wildlife trade, we believe measures should include third-party screening of selected species for high-priority diseases before importation—a measure not covered by H.R. 669. Screening would be improved by the development and/or validation of testing tools [e.g., MassTag PCR (multiple tag–based DNA amplification with the polymerase chain reaction), viral and panmicrobial microarrays, and high-throughput sequencing]. On an international scale, implementation should include groups that monitor or control the spread of nonnative hosts and pathogens to new regions such as the Invasive Species Specialist Group, Global Invasive Species Information Network, Food and Agriculture Organization of the United Nations, World Health Organization, Office International des Épizooties (OIE), nongovernmental organizations specializing in biodiversity conservation and health and others—perhaps working through a single intergovernmental agency.

Implementation of these measures can occur in a way that supports the healthy trade of wildlife, rather than acting as an economic hindrance to trade stakeholders. It could use the OIE's approach, which provides incentives (the declaration of disease-free status) to trading nations. This would likely promote ex situ captive-breeding of frequently traded animals, reducing pressure on wild populations and the risk of disease introduction.

Voluntary measures to reduce risk have been proposed. CDC's "Healthy Pets, Healthy People" Web site advises pet owners about zoonotic diseases associated with some wildlife (www.cdc.gov/healthypets). The Pet Industry Joint Advisory Council (www.pijac.org) promotes a National Reptile Improvement Plan, encouraging importers to screen animals for ticks. Such voluntary regulatory measures are a useful, but not a complete, solution and they need to include trade stakeholders, and to be independently assessed to determine success.

Collectively, risk analysis on wildlife species in trade, preborder pathogen screening, and voluntary support should go a long way to reducing costs associated with species invasion [estimated at $120 billion per year in the United States (*17*)] and to protect public, environmental, and animal health.

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