

**The Wildlife Trade – a growing threat to Global Health  
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Threats to global health and risk factors for emerging infectious diseases run the gamut from climate change to poverty to security issues, but few are as immediately manageable as one risk factor, the global trade in wildlife. Trade in wildlife provides disease transmission mechanisms at scales that not only cause human disease outbreaks but also threaten livestock, international trade, rural livelihoods, native wildlife populations, and the health of ecosystems. Quantifying the global wildlife trade is almost impossible since it ranges in scale from extremely local barter to major international routes, and much is illegal, or through informal networks. Some indicative figures for just the live wildlife trade are that each year, roughly 40,000 live primates, 4 million live birds, 640,000 live reptiles, and 350 million tropical fish are traded globally (1). Surveys of live wildlife in markets in Guangzhou, China included masked palm civets, ferret badgers, barking deer, wild boar, hedgehogs, foxes, squirrels, bamboo rats, gerbils, various species of snakes, endangered leopard cats—together with domestic dogs, cats, and rabbits (2). Following the severe acute respiratory syndrome (SARS) outbreak in 2003, 838,500 wild animals were reportedly confiscated from the markets in Guangzhou (3). Daily, wild mammals, birds and reptiles flow through trading centers where they are in contact with humans and dozens of other species before being shipped to other markets, sold locally, and even freed back in the wild as part of religious customs such as merit release (4) or because they become unwanted pets. In a single market in North Sulawesi, Indonesia, up to 90,000 mammals are sold per year (5). In a survey conducted at one market in Thailand over 25 weekends, over 70,000 birds comprised of 276 species were sold (6). A similar survey of four markets in Bangkok completed in 2001 found that of 36,537 bird observations, only 37% were from Thailand while 63% were non-native species (7). In lieu of precise trade data, we conservatively estimate that in East and South-east Asia, tens of millions of wild animals are shipped regionally and from around the world annually for food or use in traditional medicine. The estimate for trade and local and regional consumption of wild animal meat in Central Africa alone is over one billion kg per year (8) and estimates for consumption in the Amazon Basin range from 67 to 164 million kg annually (9, 10) comprising, for mammals alone, between 6.4 million and 15.8 million individuals (11). In Central Africa, estimates of the number of animals consumed by humans annually vary, but a figure of 579 million has been proposed (12).

Hunters, middle-marketers and consumers make some type of contact with each animal traded. Other wildlife in the trade is temporarily exposed and additionally, domestic animals and

wild scavengers in villages and market areas consume the remnants and wastes from the traded and to be traded wildlife. These numbers combined suggest that at least some multiple of one billion direct and indirect contacts among wildlife, humans and domestic animals result from the wildlife trade annually. The increasingly global scope of this trade coupled with rapid modern transportation and the reality that markets serve as network nodes rather than as product endpoints dramatically increase the movement and potential cross-species transmission of the infectious agents that every animal naturally hosts.

Since 1980, over 35 new infectious diseases have emerged in humans (13) or about one every eight months. The origin of human immunodeficiency virus is thought to be linked to human consumption of non-human primates (14). Recent Ebola hemorrhagic fever outbreaks in humans have been traced to index case contact with infected great apes hunted for food (15). The SARS coronavirus has been associated with the international trade in small carnivores (16) and a study comparing antibody evidence of exposure to this coronavirus demonstrated a dramatic rise from low or zero prevalence of civets at farms to an approximately 80% prevalence in civets tested in markets (17). The inadvertent movement of infectious agents due to the wildlife trade is not limited to human pathogens but also those that can infect domestic animals and native wildlife which serve as biological linchpins for environmental integrity. H5N1 Type A influenza virus was recently isolated from two mountain hawk eagles illegally imported to Belgium from Thailand (18). A paramyxovirus highly pathogenic for domestic poultry entered Italy via a shipment of parrots, lovebirds and finches imported from Pakistan for the pet trade (19). Monkeypox was introduced to a native rodent species and subsequently humans in the United States by the importation of wild African rodents from Ghana for the U.S. pet trade (20). Chytridiomycosis, a fungal disease now identified as a major cause of the extinction of 30% of amphibian species worldwide, has been spread by the international trade in African clawed frogs (21). Merit release of wild birds and reptiles that have passed through markets provides another avenue for introducing novel infectious agents into the wild (4) and warrants further attention.

Many diseases are transmitted via the same species of parasites carried by imported animals. For example, between November 1994 and January 1995, U.S. Department of Agriculture personnel inspected 349 reptile shipments from 22 countries containing 117,690 animals. Ticks were removed from animals in 97 shipments and infested shipments included 54,376 animals (22). Ticks carry many diseases that threaten livestock and human health, including heartwater disease, Lyme disease, and babesiosis.

The threat of emerging infectious diseases spreading between people and animals is rising, fueled by human activities ranging from the handling of bushmeat and the trade in exotic animals to the destruction or disturbance of wild habitat (23, 24, 25). In a list of 1415 human pathogens, 61% are known to be zoonotic and multiple host pathogens are twice as likely to be associated with an emerging infectious disease of humans (26). Seventy seven percent of pathogens found in livestock are shared with other host species (27).

In addition to the direct health effects of the pathogens on people and animals, animal-related disease outbreaks have caused hundreds of billions of dollars of economic damage globally, destabilizing trade, and having devastating effects on human livelihoods. The rash of emerging or re-emerging livestock disease outbreaks around the world since the mid 1990s, including bovine spongiform encephalopathy, foot and mouth disease, avian influenza, swine fever, and other diseases has been estimated to have cost the world's economies over \$80 billion (28). In early 2003, the United Nation's Food and Agriculture Organization reported that more than two-thirds of global meat trade was embargoed as a result of mad cow disease, avian influenza, and other livestock

disease outbreaks. Efforts to control the spread of avian influenza in Asian countries since 2003 has required the culling of more than 140 million chickens (29). The projected growth of industrial livestock production in developing countries to meet global protein demand in the coming decades will increase the economic and food security impacts of future disease outbreaks, some of which will inevitably be linked to the trade in wildlife if not effectively prevented.

Rather than attempting to eradicate pathogens or the wild species that may harbor them, a practical approach to decrease the risk for the spread of infectious diseases would include decreasing the contact among species. Closing down retail poultry markets in Hong Kong for just one day per month was demonstrated to reduce the rate of H9N2 avian influenza virus in market birds (30). Little equivalent work has been conducted in markets systems selling wildlife, but an analogous approach to the precautionary principle (31) would be appropriate for taking action prior to the next outbreak or pandemic. Since wildlife marketing functions as a system of scale-free networks with major hubs, these trading points provide practical control opportunities to maximize the impact of regulatory efforts (32). Focusing efforts at markets to regulate, reduce, or in some cases, eliminate the trade in wildlife could provide a cost effective approach to decrease the risks of disease for humans, domestic animals, wildlife and ecosystems.

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