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Reaping the Whirlwind? Human Disease from Exotic Pets

CATHERINE M. BROWN

Edward Norton Lorenz, mathematician and meteorologist, introduced in 1963 the idea that "one flap of a seagull's wings would be enough to alter the course of the weather forever."

This principle, now known as the butterfly effect, reminds us that even the flap of a butterfly's wing could create an eddy that, when amplified within the chaotic motion of the atmosphere, could ultimately cause a large-scale disturbance far from the original event. The notion has been generalized into the principle that in complex systems, such as the weather, it is impossible to accurately identify and measure every single determining factor, and therefore impossible to predict long-term outcomes.

All living organisms, from humans to pathogens, are complex systems existing within complex ecosystems. Natural variations in the interrelationships between the components of these complex systems often result in reactive counterbalancing changes that allow the ecosystem to persist. Yet ecosystems may be more frail than was once thought (Hassan et al. 2005). Outside forces that disrupt these systems can have unforeseeable consequences.

Examples of apparently small biological disruptions that have had large, unpredicted, and unintended consequences are easy to find. The introduction in Australia of only 24 European rabbits in 1859 was associated with the decline and extinction of many of Australia's midsized terrestrial mammals. Today, feral rabbits' competition and land degradation are listed as "a key threatening process" in the Australian Endangered Species Protection Act (Biodiversity Group, Environment Australia 1999). Rabbit populations currently threaten 14 different species of animals and 30 species of plants. Thomas Austin, the gentleman who released the rabbits, proved to lack prescience when he said, "The introduction of a few rabbits could do little harm and might provide a touch of home, in addition to a spot of hunting."

The brown tree snake was accidentally introduced in Guam during World War II, probably as a passive stowaway on a military cargo ship. Although it arrived in the midst of a large disruption, a single reptile species could not have been expected to be a significant problem. Sixty years later, this animal has been found to be directly responsible for the local extirpation or extinction of 9 of the 11 native forest birds on the island and 4 of the 12 native lizards. In addition, the snakes caused more than 1600 electrical power outages between 1978 and 1997, costing the economy an estimated $4.5 million per year. Last but not least, snakebites cause 1 out of every 1000 emergency-room visits on Guam; young children make up the majority of the victims (Fritts and Leasman-Tanner 2001).

Hendra virus debuted in Brisbane, Australia, in September 1994, first killing horses, then people. The disease was eventually tracked back to several species of flying foxes, frugivorous bats native to the forested areas around Brisbane. Research indicates that the virus is old, and must have coevolved with its hosts over several thousands of years. How did it make the jump to other species? Why now? The answer is deceptively simple: Expanding human development resulted in deforestation, which reduced the number of fruit trees available for the flying foxes to eat from and roost in. In the pasture once used by the horse that was the equine index case, a single fig tree remains, a tree that served equally well as a roost for a bat and a sunshade for a horse. The virus, in its now disturbed ecosystem, made the leap.

The Centers for Disease Control and Prevention estimate that 60 percent of the currently known human pathogens and 75 percent of emerging infectious pathogens are zoonotic; they include rabies, plague, leptospirosis, tularemia, West Nile virus, Ebola, Marburg, SARS, and Nipah (CDC 2007). Even domestic cats and dogs can serve as a source of human disease, but the risks posed by Fluffy and Fido are well known and understood. These species have been the companions of humans for thousands of years, and, at least in the developed world, most of the risks from them can be controlled: vaccinating prevents the spread of rabies, deworming kills the intestinal parasites that cause ocular or visceral larval migrans, and applying insecticides repels ticks that spread the agent of Lyme disease.

Cats and dogs are no longer the only pets found in US homes, however. The Captive Wild Animal Protection Coalition estimates that 10,000 to 20,000 large exotic felids, 17.3 million birds, 8.8 million reptiles, and 3000 great apes are being kept as pets in this country. In 2005 alone, 210 million animals were legally imported into the United States to satisfy the growing demand for exotic species. An unknowable number of pets, animal parts, and meat were smuggled in during the same time period, making up a large part—a portion ranked second only to the illegal drug trade—of the estimated $10 billion per year international black market (Ebrahim 2006).

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Introducing so many animals into a new and unnatural environment—our homes—after removing them from the ecosystems in which they evolved represents a disruption of substantial magnitude. This displacement brings these animals into close proximity with species they have not previously encountered, and the public health consequences may be startling.

The most famous, or perhaps infamous, example is the outbreak in the United States of monkeypox in humans, a result of humans' close contact with prairie dogs sold as pets. Human monkeypox, which in its original environment affects primarily children, has a clinical course similar to that of smallpox, although its fatality rate is lower. This disease, which had not previously been seen outside of Africa (where exposure is thought to take place through contact with wild rodents), was diagnosed in 81 patients in the American Midwest during the summer of 2003. It turned out that Gambian giant rats, imported into the United States for the pet trade, had been housed next to prairie dogs. Asymptomatically infected rats transmitted the virus to the prairie dogs, which then passed it along to the humans who brought them home. Curiously, no suspected, probable, or confirmed cases of monkeypox occurred in humans who had contact only with the Gambian rats, or with any other African rodents (CDC 2003).

Clearly, the surprising thing is not that monkeypox infected US residents, but that such cases have not arisen more often. With our penchant for sharing our living spaces with creatures from foreign lands, outbreaks of other diseases will surely occur. What isn't clear is how to best protect ourselves.

One approach, the one used most often to augment the generic requirement for a health certificate, is to regulate and legislate for known risks—it is now illegal to import African rodents into the United States, for example. Unfortunately, this approach is reactive rather than proactive, because it relies on the transmission of disease to humans—exactly what we are trying to prevent.

A more proactive alternative would be to regulate the unknown risks—in other words, prevent the importation of species (and thus the pathogens they harbor) that are not well understood. The precautionary principle supports this approach: it puts the onus on the importers and the eventual owners either to prove that a particular species does not have the potential to cause harm, or to provide ways to mitigate any risk. A third approach, a complete ban on importing exotic species for pets, has also been proposed, but is strongly opposed by both potential owners and members of the pet-trade industry. No matter which approach is eventually taken, however, it would be prudent to remember the already vast scale of the illegal market.

There are myriad other important matters relating to the importation of exotic pets, of course—animal welfare issues, physical injury of humans, and disruption and destruction of native wild populations by escapees, among others. My intention in this Viewpoint, however, is not to assign a hierarchy of importance to these factors; rather, I want to highlight one particular area of concern. When it comes to infectious disease and exotic animal imports, it is clear that what we don't know *can* hurt us. Addressing this threat of the unknown effectively will require proactive, and perhaps politically unpopular, measures.

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Correction

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