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## Lions, Tigers and Bears: The Global Trade in Animals

When you have got an elephant by the hind legs and he is trying to run away, it's best to let him run.

—Abraham Lincoln

### **An elephant never forgets**

On 20 August 1994, an international uproar was caused by an incident involving a female African elephant who went on a rampage in Honolulu, Hawaii.<sup>1</sup> The animal, Tyke, was 'performing' during an event for Circus International when, before hundreds of horrified spectators, she grabbed her trainer, thrashed him about and killed him before turning on her groomer and goring him. She then ran from the arena and escaped to city streets, where for 30 minutes she caused havoc and threatened the public before police shot her almost 100 times. It took her two hours to die.<sup>2</sup>

Why did Tyke, after years of performing for this circus, suddenly turn and attack the two people with whom she had spent most of her circus life? To answer this, it might help to take a look at the life she led up until that fatal day. Tyke's keeper, John F. Cuneo Jr., owned Hawthorn Corporation, one of the largest suppliers of performing elephants and tigers in the USA.<sup>3</sup> While most of Tyke's life history with Hawthorn Corp. is not publicly known, that of Lota, another elephant kept by the company, is. In 1952, she was captured from the wild as a baby in India and torn from her family.<sup>4</sup> Lota lived her first two years in captivity in a zoo in India before being shipped to the Milwaukee County Zoo in the USA, where she spent the next 36 years of her life with three other female elephants.<sup>5</sup> At the Milwaukee zoo, the three elephants were routinely chained by two legs to the floor of their barn for at least 18 hours a

day. Zoo staff conducted videotaped training sessions for new employees in which the elephants were repeatedly struck by bullhooks.

Over time, Lota became too aggressive for the zoo to handle. In 1990, she was sold for US\$1 to Hawthorn Corp.<sup>6</sup> In a widely publicized video, she was shown being beaten and dragged into a trailer as she fought her chains, which finally broke, sending her falling backwards and then sliding beneath the trailer. This video footage caused an international outcry and repeated pleas that the elephant be sent to a sanctuary. Despite the pleas, Hawthorn would not relinquish Lota and she was kept in chains throughout her life, being dragged around and rented out to one venue after another to perform. In 1996, she contracted tuberculosis. In 2001, a US Department of Agriculture (USDA) inspector cited Hawthorn for failure to provide veterinary care to Lota, who was 'excessively thin, with a protruding spine and hip bones and sunken in eyes'.<sup>7</sup> No improvement in her condition was made, however. Returning later that year, the USDA again noted Lota's dismal state, reporting that she was in a 'perilously emaciated state, with a wound on her left hip'. The elephant died from tuberculosis in 2005.

Based on Lota's experiences, it seems likely that Tyke's life was similarly wretched under the care of Hawthorn Corp. A report in *Nature* reveals that elephants, when exposed to violence and psychological and social trauma, can suffer from post-traumatic stress disorder.<sup>8</sup> Could it be that Tyke, after a lifetime of physical and mental suffering, intentionally lashed out and sought revenge upon those who had harmed her? Or was her attack the result of general psychological illness produced by years of confinement, captivity in sterile environments and physical abuse? We will never know why Tyke lashed out, but we do know that Lota's experiences are by no means an exception. Today, thousands of wild or exotic animals are kept in zoos, circuses, marine amusement parks and private residences. Many are used to supply hunting ranches and game parks around the world. These animals are either caught from the wild or bred in captivity and traded around the globe to ensure an ever-ready supply. This is the global trade in wildlife, and all indications are that our infatuation with exotic and wild animals is coming back to bite us.

## **The wildlife trade**

Unlike dogs, cats and cows, who have been domesticated over centuries, a wild animal is one who has not been domesticated to live with humans. Thus wild animals include not only free animals who are then captured but also animals who have, only in relatively recent

times, been bred in captivity by humans. In this chapter, we will explore not only how the global wildlife trade poses significant public health risks but also how it causes immense suffering in animals. The trade is directly and indirectly leading to a rapid rise in new infectious diseases, the spread of existing diseases, injuries in people and the loss of species at a rate never before seen. As we delve deeper into the world's forests and jungles to capture, kill and collect animals for the trade, we are inviting pathogens never before encountered to jump into the human population and wreak havoc. As we rip animals from their natural habitats, we are disrupting ecosystems in profound and perhaps irreversible ways, which will in turn cause a surge in some very deadly infectious diseases. And, as we ship billions of animals around the globe, we are ensuring that any diseases unleashed by this trade will impact humans everywhere.

Every year, billions of animals are caught from the wild or bred in captivity and then traded or slaughtered in the wildlife trade.<sup>9</sup> They are used live or sold in body parts as pets, entertainment, food, skins, ornamental or medicinal objects, and biomedical research subjects. They are also stocked on hunting ranches to be slaughtered in 'canned' hunts, in which hunters pay fees to shoot and kill exotic animals in a confined area from which the animals are unable to escape. The global trade in animals involves an unprecedented number and array of species, including non-human primates (NHPs), other mammals, birds, amphibians and reptiles. The trade occurs both globally and within countries, and all indications are that it is rapidly increasing worldwide.<sup>10</sup> The drive behind the exotic animal trade is big money, estimated at anywhere from US\$10 billion to more than US\$40 billion annually.<sup>11</sup>

The USA is by far the largest consumer of wildlife.<sup>12</sup> An analysis of the US Fish and Wildlife records revealed that the USA imported more than a billion animals, including fish, between 2000 and 2004.<sup>13</sup> Excluding fish, more than 180 million animals were imported during that time. Another analysis reports that among mammals, about two-thirds are imported for commercial purposes and one-third for biomedical research.<sup>14</sup> In addition to being the largest importer of wildlife, the USA is also, paradoxically, the largest exporter of wildlife.<sup>15</sup> For example, between 1989 and 2007, the USA exported almost 58 million live reptiles.<sup>16</sup> The number of exports of reptiles from the USA doubled between 1989 and 2007. After the USA, the world's other wealthiest and most developed nations, including those in Europe, China and Japan, are not far behind in their consumption of wild animals.<sup>17</sup> A review of customs data in China revealed a sharp increase in the number of live

turtles imported between 1998 and 2002;<sup>18</sup> in 2002 more than 2 million live turtles and tortoises were imported. Other nations have similarly been seeing an increase in the importation, exportation and/or regional trading of wildlife over recent years, particularly in Southeast Asia, a 'hot spot' of exotic species.<sup>19</sup>

The Convention on International Trade in Endangered Species (CITES) has regulated the trade of wildlife across borders since 1973.<sup>20</sup> Its purpose is to prevent the trade from threatening endangered animals and plants.<sup>21</sup> The treaty contains three appendices in which restricted species of plants and animals are listed. The degree of restriction placed on the trading of a species depends on which appendix that species is listed in. In all, about 5000 animal species are listed in any of the three appendices. Although nations may supplement CITES agreements with further regulations or bans on importation and exportation of animals, any enforcement of CITES relies largely on individual nations, many of which lack sufficient resources to uphold restrictions.<sup>22</sup> Thus, in reality, only a limited number of regulations protecting the listed species are actually enforced.

Simply put, virtually any animal is fair game and no region in the world is immune from the health repercussions of the trade. This chapter will focus on three main issues concerning the wildlife trade:

1. how wild animals kept as pets and entertainment are causing injuries and death, particularly in children;
2. how the wildlife trade is contributing to the emergence of some of our deadliest infectious diseases; and
3. how the trade causes the loss of biodiversity that, in turn, has rippling public health effects.

### **Our fatal attraction**

Very often, the more exotic or wild the animals, the more intriguing they seem to us. It's hard not to be charmed by a tiger or even a baby iguana. Unfortunately, their allure can lead to fatal consequences. There have been numerous reports about horrifying attacks by wild or exotic animals kept as pets, housed on hunting ranches or used for entertainment. There are countless stories around the world like the following:

- In December 2003, a bear who performed at a children's theater in Moscow killed a trainer as he entered the animal's cage to feed him.<sup>23</sup>

- In 2008, a grizzly bear named Rocky, who appeared in the Will Ferrell movie *Semi-Pro*, was being filmed for a promotional video for the wild animal training center. The bear attacked and killed his handler by taking a lethal bite out of the man's neck.<sup>24</sup> Prior to this, Rocky was described as a 'loving, affectionate, friendly, safe bear'.
- In January 2010, a Canadian man who kept exotic cats in cages behind his farmhouse went out to feed a Bengal tiger and never returned.<sup>25</sup> Several years earlier, he had challenged a ban on keeping exotic animals after one of the tigers kept on his premises attacked a ten-year old boy during a photo opportunity.<sup>26</sup> The man won the court case and had the ban overturned, but he lost his life in 2010: he was found dead in the tiger's cage.

These examples are just a tiny sample and, unfortunately, children are especially vulnerable to such attacks. Because of their smaller size, kids are much more likely to be seen as prey. For example:

- In April 2009, a wolf performing on stage in California for a show by the company Amazing Animal Productions lunged at a two-year old girl in the audience, biting her neck and face.<sup>27</sup> Fortunately she survived, but other children have not been so lucky.
- In August 1999 in Illinois, a three-year-old toddler was strangled to death by the family's 7.5 foot African rock python.<sup>28</sup>
- In 2003, a ten-year-old boy was shoveling snow near a cage containing a 400 lb Bengal tiger outside his aunt's home.<sup>29</sup> The boy got too close and the tiger dragged him under a fence, into his cage and mauled him to death.

Despite numerous similar stories of severe human injuries and death, the trade in wild animals as pets and entertainment continues to flourish and expand. The global wildlife trade of pets alone is estimated to involve at least 350 million live animals annually.<sup>30</sup> Here again, the USA takes the lead in the number of wild animals kept as pets. According to a survey conducted by the American Pet Product Manufacturers Association, 18.2 million wild animals were kept as pets in 2004, an increase from 16.8 million in 2002.<sup>31</sup> Thousands of wild mammals, such as tigers, lions, wolves and NHPs, are kept in American homes.<sup>32</sup> Born Free USA, a non-profit animal protection organization, estimates that between 5000 and 7000 tigers are kept in private homes in the USA.<sup>33</sup> If correct, this means more tigers live in American households than exist in the wild. But the USA is not alone in its love affair with wild animals. As incomes

rise elsewhere in the world, so too does the trading and keeping of exotic animals as pets and entertainment, particularly in Europe and Asia.<sup>34</sup>

It's extremely easy to purchase a wild animal. Perusing the Internet will reveal chat rooms, auction sites and dealer sites where one can find a Noah's Ark of animals for sale.<sup>35</sup> Looking for a baby python? They come cheap. At the time of writing, a baby python can be found online for about US\$25. Bearded dragons can be purchased for \$75. And with a little more ready cash, baby marmosets and capuchin monkeys are available for as little as \$350 and tigers for \$1000. Swap meets, newspaper ads, fairs and pet stores are other sources.

It's hardly surprising to learn that animals from the wild are inherently unsafe to have around humans. No one would suggest that it is a good idea to unwittingly approach an elephant roaming free in the African savannah. So why do we abandon this common wisdom when it comes to elephants and other wild animals in zoos, circuses and private households? Additionally, although it is difficult to establish a direct causal relationship, the way we treat wild animals may be, at least in part, responsible for the thousands of attacks on humans each year. Most animals captured from the wild to be used in entrainment or in private households are captured as infants. In order to capture wild baby animals, their family members are frequently killed, often in full view of the young.<sup>36</sup> For social creatures such as NHPs and elephants, witnessing the killing of their parents and other family members, followed by separation from their natural environment, can be extremely traumatizing and may cause a lasting impact on an animal's behavior, which can endanger humans. Removed from their natural habitats, a captured animal may be passed from one broker to another several times before being shipped, regionally or internationally, and experiencing extremely cruel transport conditions.

As bad as a captured animal from the wild has it, animals raised in captivity aren't necessarily treated any better, nor are they safer for us. Although NHPs are banned from importation into the USA for the pet trade, they are widely bred there.<sup>37</sup> Charla Nash was mauled by her friend's pet chimpanzee, Travis, on February 16, 2009.<sup>38</sup> He attacked Nash without apparent provocation, ripping off her hands, nose, lips and eyes before fleeing. He was later shot to death. Nash survived, but she is now blind and severely disfigured. Travis had been surrounded by humans his entire life. He was born at the Missouri Primate Foundation, the largest chimpanzee-breeding compound in the USA.<sup>39</sup> The compound, in addition to breeding and selling chimps, rented them out to parties.<sup>40</sup>

No matter the circumstances, by their very nature, non-domesticated animals are dangerously unpredictable. A large part of this unpredictability may be due to how we treat them. Regardless of whether they were taken from their natural habitats or bred in captivity, wild animals kept as pets and in private collections are usually subject to woefully inadequate care, neglect or outright abuse. Most buyers know little about the animals' needs and care requirements, and they are unprepared or unable to provide for them. Birds are most often housed in small cages, depriving them of the very thing that defines them: flight.<sup>41</sup> Caged birds routinely display abnormal behaviors, such as self-mutilation and stereotypies (repetitive movements, such as pacing). NHPs and birds—social animals by nature—may live their entire lives separated from others of their kind and in unnatural, small and bare environments.<sup>42</sup>

Perhaps more disturbing is the ease with which buyers dispose of their exotic pets. One morning in July 2010, a custodian at a Boston high school was cleaning the school lockers.<sup>43</sup> The school was closed for the summer. Imagine the custodian's surprise when a hissing, very irate python fell out of one the lockers onto his feet! A student had abandoned the python in his locker. Several years before the python was found in the locker, a parrot was found abandoned in a nearby automated teller machine. People frequently buy baby snakes, tiger kittens or other animals, only to learn that they quickly grow into extremely large and/or difficult-to-handle adults.<sup>44</sup> Many of those 'cute' baby pythons will quickly grow to 15 feet in length. As the growing animals become unmanageable, they are often kept in chains or small pens and may be beaten into submission. Many are eventually abandoned or left to languish in cages, or die due to physical abuse or inadequate care.<sup>45</sup>

Despite many people's perceptions to the contrary, animals kept for public display or entertainment are often treated no better than those kept in private households. Returning to the two elephants for a moment, it was previously mentioned that Lota's experiences in zoos and circuses are anything but exceptional. Ten years after Tyke's death (she was the elephant who rampaged), John Cuneo Jr., the owner of Hawthorn Corporation, was charged by the USDA with a litany of animal welfare violations, including serious charges, such as mishandling that caused physical harm, discomfort and trauma to the elephants and that created a risk for both these animals and the public.<sup>46</sup> Cuneo admitted guilt, he was fined US\$200,000 and 16 elephants were removed from his care. This admittance came years after repeated incidents of

elephant rampages, multiple shipments of sick elephants infected with tuberculosis and cruelty to animals.

Animals captured for zoos, circuses and other forms of entertainment are routinely beaten to tame them into submission and to force them to perform.<sup>47</sup> One rather typical case occurred in 1998 when an elephant dealer captured 30 baby elephants in Botswana and shipped them to his warehouse in South Africa.<sup>48</sup> There, he deprived them of food and water and beat them as part of his training process to prepare them for life in captivity. Seven were sold and shipped to zoos in Europe before the dealer was successfully charged with animal cruelty.<sup>49</sup> The so-called 'greatest show on earth', Ringling Brothers and Barnum and Bailey Circus, has been abusing animals for years. Former employees have accused the circus of whipping elephants and beating them with bullhooks, and chaining them for days at a time.<sup>50</sup> USDA inspection reports have repeatedly cited zoos and circuses, including Ringling Brothers, for the deplorable conditions in which they house animals, lack of veterinary care for sick animals, inadequate testing for tuberculosis, lack of vaccinations and physical abuse of animals.<sup>51</sup> To make matters worse, many of the reports cite inadequate safety barriers between animals and the public. All of these factors place the public at risk of not only injury but also infectious diseases. Indeed, some citations were for the actual harms caused to the public. Despite these violations, however, most of these zoos and circuses are still in business.

The typical life of an animal in a traveling zoo or circus involves being kept for months in a small, barren cage, tightly chained for many hours every day, while being trucked from one venue to another.<sup>52</sup> Roadside and non-traveling zoos, particularly the smaller ones with poorly trained staff and inadequate budgets, are notorious for keeping animals in deplorable conditions.<sup>53</sup> Animals are often found lying in their own filth with little food and water. Social animals may be kept in isolation and other animals may be crammed into cages. Even those lucky enough to be in better zoos may eventually end up in the hands of entertainment companies and private collectors if they are deemed as zoo surplus or 'difficult to handle'.

Some, primarily those who profit from using animals as entertainment, contend that such zoos, circuses and other entertainment venues provide education about animals and teach people to appreciate them.<sup>54</sup> Yet there is little evidence to support such claims and, arguably, the opposite is true. Watching an elephant perform handstands or tigers jumping through flaming rings of fire hardly seems to confer respect for animals. Video footage of animals in their natural environments



reveals much more about them and helps foster understanding and appreciation of who they truly are.

It is evident that private collectors and entertainment venues are putting the public at peril. One lawsuit (among many) brought against Hawthorn Corp. was on behalf of plaintiffs, many of whom were children, who suffered psychologically as a result of witnessing Tyke's killings.<sup>55</sup> This suit was settled out of court. In 2003 a Bengali tiger named Montecore sank his teeth into Roy Horn's neck (of the famous 'Siegfried and Roy' animal act) and dragged him off stage in front of a horrified audience in Las Vegas. The USDA stated in its final investigation report that the show failed to protect the audience because it had no barrier separating the animals from the crowd.<sup>56</sup> 'The big cats could have easily jumped off the stage and into the audience,' said USDA official Robert M Gibbens who had attended an earlier performance. A chimpanzee named Suzy (the mother of Travis, the chimpanzee who attacked Charla Nash) escaped from the Missouri Primate Foundation compound with two other chimpanzees and was gunned down by a teenager after they turned on him.<sup>57</sup>

Behavioral problems and physical illnesses are common among all wild animals kept as pets or used for entertainment. These issues are primarily a result of their living conditions, malnutrition, abuse and stress.<sup>58</sup> Given these conditions, it's not surprising that animal attacks occur. Even though it is difficult to directly connect our treatment of animals with these attacks, we can establish with little doubt that just keeping wild animals as pets and entertainers is incredibly risky. Primatologist Frans de Waal, after being asked why Travis may have become violent, had this to say:

A chimp in your home is like a time bomb. [He] may go off for a reason that we may never understand... Usually these animals end up in a cage... even if a chimp were not dangerous, you have to wonder if the chimp is happy in a human household environment.<sup>59</sup>

The bottom line is that no matter how much we think we know a wild animal, and no matter how much we think we are providing an adequate environment, we probably don't and can't.

Of course, even animals domesticated over eons can, and do, attack humans. Often this occurs because of direct provocation or because those animals were specifically trained to be aggressive. But, over thousands of years, we have come to understand the needs of and behavior of domesticated animals far better than those of other animals. In addition

they have learned to live with us. This greater understanding on both sides helps to minimize harm. This is not the case with wild animals. With few exceptions, we don't know how to, don't care to or simply can't provide appropriate, rich and safe environments for wild animals.

Admittedly, the total number of human injuries and deaths caused by wild animals kept in captivity is relatively low in comparison with other causes of injuries, such as motor vehicle collisions. However, and more importantly, the animals' poor health that results from our maltreatment leads to another, even more significant public health problem. An even greater danger lurks behind the wildlife trade; one that not just impacts individuals or small groups but threatens the entire globe: infectious diseases.

### **The rise in infectious diseases**

In the past few decades the world has witnessed an unprecedented surge in emerging infectious diseases (EIDs), such as AIDS, SARS, Ebola, 2009 H1N1 (commonly referred to as 2009 swine flu) and H5N1 (or avian influenza). EIDs are defined as the emergence of new or previously unrecognized infectious diseases, the resurgence of a previously known disease in a given place or population, or the emergence of a known disease in a new population.<sup>60</sup> In the past three decades alone we have seen a resurgence of a number of long-known infectious diseases, such as malaria, tuberculosis and cholera, in regions where they were thought to have been successfully eradicated. We have witnessed the emergence of infectious disease agents in novel places, such as West Nile virus for the first time in the USA in 1999. And we have discovered new infectious agents, such as the Nipah virus and the severe acute respiratory syndrome (SARS) coronavirus.<sup>61</sup> Since 1980, more than 35 new infectious diseases have emerged in the human population and 87 human pathogens have been discovered—that's an average rate of about three new pathogens each year.<sup>62</sup>

Why are we seeing such a rise in infectious diseases? Several factors are to blame. First, some of the diseases may not be new at all; they could have circulated among humans for centuries. Yet they are being identified for the first time because of increased surveillance, reporting and modern laboratory diagnostic techniques. While this is certainly true in some cases, Jones et al. found that even after controlling for increased surveillance and reporting, there has still been a significant increase in EIDs in recent times.<sup>63</sup> Their study supports other reports that infectious diseases are indeed on the rise and are becoming an increasing public

health threat. Second, the human population is exploding throughout the world—the current population count puts it at about 7 billion and is estimated to increase to almost 10 billion by 2050.<sup>64</sup> As our population grows, available land shrinks and more and more people are forced to live in crowded, urbanized environments, a situation ripe for the easy spread and emergence of infectious agents. Third, HIV/AIDS has enabled a spike in opportunistic infections, which would otherwise occur at very low rates in healthy populations. Fourth, increasing antimicrobial resistance is spurring the development of ‘superbugs’. Fifth, humans are traveling around the globe as never before. Our travels significantly increase our chances of catching a disease in one area and unwittingly transporting the infectious agent to another area, where it was never before seen and where little or no immunity exists.

The sixth and seventh factors are climate change and natural habitat loss, which contribute to the rise and spread of several notable infectious diseases. This is particularly evident with vector-borne diseases. These are diseases that are transmitted to humans and other animals by insects and other arthropods, such as mosquitoes, spiders and ticks. A vector’s life cycle greatly depends on climatic factors.<sup>65</sup> It turns out that climate change is helping certain vectors to flourish. As a result, some significant infectious diseases are on the rise. Deforestation, land use changes and rapidly changing weather patterns resulting in high rainfall or drought are believed to be causing surges in malaria, dengue fever and Buruli ulcer disease.<sup>66</sup> Cleared land collects rainwater better than rainforests, providing more suitable breeding grounds for malaria-transmitting mosquitoes.<sup>67</sup> Deforestation favors the growth of *Schistosoma*, which is a parasitic worm.<sup>68</sup>

Rising temperatures are at least partially contributing to the rise in outbreaks of mosquito-borne diseases, such as malaria, yellow fever and Saint Louis encephalitis.<sup>69</sup> By shortening the incubation time of these viruses within mosquitoes, accelerating the maturation of mosquito larvae and increasing the feeding frequency of adult mosquitoes, warmer temperatures favor the transmission of the viruses. As will be described later, our encroachment upon and fragmentation of woodland habitats in the northeastern USA is implicated in the rise of Lyme disease.<sup>70</sup> The Nipah virus is a newly discovered pathogen that is causing considerable public health concern because of its ability to infect a broad range of animals and its high lethality among humans.<sup>71</sup> It was first detected in a Malaysian village, where it caused severe encephalitis and high mortality in humans. Habitat loss is believed to have caused a mass exodus of Nipah virus-carrying *Pteropus* ‘flying fox’ (or fruit bats) as they searched

for food.<sup>72</sup> This led the bats to cultivated fruit farms that were planted next to pig farms to allow for the use of the pig manure as crop fertilizers. Unfortunately, the pigs were highly susceptible to the Nipah virus and passed it on to humans.

While these seven factors do indeed contribute to the rise in EIDS, an eighth is rapidly gaining in importance and may be paramount: the global and regional trade in, and production of, animals. As our demand for animals for food, skins, fur and entertainment increases, so does our risk of infectious diseases. Chapter 4 will explore how changes in animal agriculture are contributing to EIDs. The current chapter will focus on the wildlife trade, which is significantly increasing the potential for human contact with existing and, most importantly, novel zoonotic pathogens. These are infectious disease agents that jump from other animals to humans (or vice versa). Most of the known human pathogens are classified as zoonotic.<sup>73</sup> And, of the 175 human pathogens (bacteria, parasites and viruses) that have been classified as emerging or re-emerging, three-fourths come from non-human animals. A 2005 editorial in *The Lancet* proclaimed: 'all new infectious diseases of human beings to emerge in the past 20 years have had an animal source'.<sup>74</sup>

### **Bushmeat, HIV and Ebola**

Arguably, most of the potential pathogens roaming the globe have not yet been encountered by humans. 'For every virus that we know about, there are hundreds that we don't know anything about,' said Dr Dan Bausch, a professor at the Tulane School of Public Health and Tropical Medicine, who studies the Marburg and Ebola viruses and other emerging pathogens in Africa.<sup>75</sup> 'Most of them, we probably don't even know that they're out there.' But as we move deeper and deeper into forests, savannahs and jungles to seize animals for the trade, we risk exposure to exotic insects and animals that may carry novel infectious agents. If the situation is right (or wrong, depending on how we look at it), those pathogens can pass into the human population and spread like wildfire. HIV is a perfect example. Before 1981, scientists never knew such a virus existed. While no one knows the exact sequence of events that led to the first human HIV infection, there is substantial evidence to suggest that it was contact with NHPs through the bushmeat trade that started what is now one of the most significant and devastating pandemics we have ever experienced.<sup>76</sup> More than 65 million people have been infected with HIV and more than 25 million have died.<sup>77</sup>

Worldwide, AIDS is the leading cause of premature death among people aged 15–59 years.

Bushmeat traditionally refers to animal meat derived from the African ‘bush’ or forests, particularly in Western and Central Africa. Animals typically taken for meat include chimpanzees, gorillas, other NHPs, reptiles, antelopes, rats and bush pigs. However, the bushmeat trade is not restricted to Africa; it is spreading throughout Asia and South America.<sup>78</sup> And, recently, shipments of wild animals for meat have been entering US and European ports.<sup>79</sup> In addition to the bushmeat trade, countless wild animals are shipped regionally and worldwide to supply the growing demand for ornamentation, hunting trophies and traditional medicines. Medicinal products are often derived from the body parts of animals, including endangered species.<sup>80</sup> Examples include bile derived from bears for cardiac illnesses, tiger bones for arthritis and pain, tiger penises for impotency and geckos for diabetes.<sup>81</sup>

Although indigenous groups have been living off wild animals for food, ornamentation and traditional medicines for centuries, several recent changes have led to an unprecedented surge that has become far from sustainable and is dangerous to the health of all.<sup>82</sup> Rapid population growth and increased numbers of wealthy populations in Africa, Asia and elsewhere are creating a strong urban demand for such products.<sup>83</sup> Additionally, logging industries have helped transform bushmeat hunting into a commercial operation and have increased both demand for and access to bushmeat. The logging industries bring roads, trucks, hungry workers, their families and hunters into forested areas that were once inaccessible.<sup>84</sup>

As a result of these combined factors, the trade in wild animal products has become a very profitable enterprise: hunting is cheap and the market price of wild animal products is high.<sup>85</sup> In 2008, the sale of African bushmeat alone was a US \$15 billion industry.<sup>86</sup> The economic incentive for bushmeat has shifted hunting from a subsistence activity to large-scale commercial enterprises, often by para-militarized groups, with far greater numbers of animals killed than ever before.<sup>87</sup> Bowen-Jones et al. described the shift aptly: ‘money rather than food is now often the prime motivation for hunters’.<sup>88</sup>

The increased hunting of wild animals is creating a ripe opportunity for new pathogens to enter the human population. Virus hunter Nathan Wolfe described how pathogens might jump from monkeys to chimpanzees. In a Ugandan forest, Wolfe and his colleagues witnessed a group of chimpanzees feasting on a freshly killed monkey:

Any disease-causing agent present in that monkey now had the ideal conditions under which to enter a new type of host: the chimps were handling and consuming fresh organs; their hands were covered with blood, saliva and feces, all of which can carry pathogens; blood and other fluids splattered into their eyes and noses. Any sores or cuts on the hunters' bodies could provide a bug with direct entry into the bloodstream.<sup>89</sup>

Replace chimpanzees with human hunters in this scenario and we can see how viruses can easily jump from NHPs and other animals to humans. As hunters and their families butcher and prepare animals for food, many opportunities for pathogen entry exist. All methods of killing animals can expose humans to novel pathogens. Animals captured for the trade, whether for meat, medicines or ornamentation, are routinely poisoned, snared or bludgeoned to death for their bodies or body parts.<sup>90</sup> Each year, thousands of animals are kept in cramped cages for a brief time before being skinned alive or killed by gassing, stomping, electrocution or strangling for their fur or skin.<sup>91</sup> While being killed in these ways, animals frequently soil themselves and release other bodily fluids, which may harbor zoonotic pathogens.

In his article for *Mail Online*, reporter Tom Rawstone described the killing of one python for his skin in a slaughterhouse in the Indonesian jungle:

The snake is stunned with a blow to the head from the back of a machete and a hose pipe expertly forced between its jaws. Next, the water is turned on and the reptile fills up, swelling like a balloon. It will be left like that for ten minutes or so, a leather cord tied around its neck to prevent the liquid escaping. Then its head is impaled on a meat hook, a couple of quick incisions follow, and the now-loosened skin peeled off with a series of brutal tugs—much like a rubber glove from a hand. From there the skin will be sent to a tannery before being turned into luxury shoes or handbags.<sup>92</sup>

At open markets, where animals are sold live and then butchered on the premises, it is common practice to kill animals by skinning and disemboweling them alive.<sup>93</sup> These methods of slaughter are messy (not to mention horrendously inhumane) and provide many routes by which a pathogen might infect the person doing the killing. Whatever method is employed, every time we handle and slaughter a wild animal there is an opportunity for a new pathogen to enter the human race.

In 1999 a team of investigators reported that they isolated the Simian Immunodeficiency Virus (SIV) in a subspecies of chimpanzees, *Pan troglodytes troglodytes*, in central Africa.<sup>94</sup> Through molecular analysis, they found that the SIVcpz strain closely matched HIV-1, the predominant HIV strain that infects humans. The investigators concluded that SIVcpz is the precursor to HIV and that this subspecies of chimpanzee is the natural reservoir and source of at least three independent virus cross-species transmission occurrences from chimpanzees to humans. We were most likely first infected by exposure to contaminated animal secretions, tissues and blood through hunting, butchering and/or consuming infected chimpanzees.<sup>95</sup>

More recent studies suggest that human exposure to SIV is ongoing and that cross-species transmission occurs more frequently than previously thought. Peeters et al. took blood samples from 573 freshly butchered monkeys sold in bushmeat markets in Cameroon and nearby areas.<sup>96</sup> They also tested blood from 215 wild monkeys kept as pets. They found that almost one in five monkeys sold for bushmeat and more than one in ten sold as pets showed evidence of infection with different SIV strains. They also found that many more species of NHPs than previously thought are infected with SIV and that there are many SIV subtypes. A study of people in 17 villages in Cameroon found that exposure to NHPs is substantial and is not confined to hunters but also occurs among their family members and many others who butcher animal carcasses and prepare the meat.<sup>97</sup>

One of the features of viruses and bacteria that is especially difficult to combat is their ability to adapt to new environments through rapid genetic mutations. The alarming rise in antibiotic-resistant bacteria is a result of bacteria adapting to and surviving antibiotics through genetic mutation. The greater the genetic variability in a species, the greater the chance that some individuals will survive an environmental—or, in this case, pharmacologic—assault. Those strains of bacteria with the right genes to help them survive an antibiotic will pass on their genetic makeup to successive generations, which will then flourish and become the bane of doctors and hospitals everywhere.

When it comes to the ability to survive, of all life forms on earth, viruses are probably about as perfect as it gets. Actually there is a debate as to whether or not viruses should be classified as life forms. Either way, viruses are master replicators. In 24 hours, one virion (a single virus particle) replicates to become ten billion virions—that's a replication rate of almost 116,000 per second! This high replication rate

makes viruses especially good at mutation and adaptation. According to the National Institutes of Health medical epidemiologist David Morens,

when you look at the relationship between bugs and humans, the more important thing to look at is the bug. When an enterovirus like polio goes through the human gastrointestinal tract in three days, its genome mutates about two percent. That level of mutation—two percent of the genome—has taken the human species eight million years to accomplish. So who's going to adapt to whom?<sup>98</sup>

Unfortunately for us, three-fourths of all new human pathogens that have emerged since 1980 are viruses.<sup>99</sup> This forecasts a very troubling future. As geneticist and Nobel prize winner in medicine Joshua Lederberg says, 'the single biggest threat to man's continued dominance on the planet is a virus'.<sup>100</sup>

Human T-lymphotrophic viruses (HTLV) cause several types of adult leukemia and neurological illnesses in humans. Like, HIV, HTLV is a retrovirus. These are transmitted through blood and body secretions. Retroviruses insert themselves into the hosts' (in this case, humans') DNA through a process that allows them to frequently mutate and to continuously evolve and adapt to new environments. Their high mutation rate and their ability to hide inside the host's own cells make them extremely difficult to eliminate, as is evident with our experience with HIV.

HTLV originated from the simian T-lymphotrophic viruses.<sup>101</sup> A recent investigation of 11 rural villages in Cameroon by Nathan Wolfe and his team found that of 200 people interviewed, almost 40 percent reported exposure to NHP blood and secretions, mainly through hunting and butchering.<sup>102</sup> Blood samples from the villagers revealed widespread infection with HTLV, as well as two previously unknown retroviruses. In another study, Wolfe and his team found evidence of Simian Foamy Virus (SFV) infection in individuals in Cameroon.<sup>103</sup> This is another retrovirus of NHP origin and is widespread among African NHPs. SFV has also been found, not infrequently, in blood samples from laboratory and zoo workers exposed to NHPs.<sup>104</sup>

Because of our close genetic relationship with other primates, we are often especially vulnerable to contracting the pathogens they carry. Cameroon, and indeed all of Central Africa, is home to some of the



highest densities of NHPs and is considered a hot spot for a host of new zoonotic diseases.<sup>105</sup> Already we have witnessed, from Central Africa alone, the emergence of some notable zoonotic pathogens, including Marburg, Ebola, monkeypox, HIV, HTLV and SFV. A novel poxvirus, a member of the same viral family as smallpox, has recently been discovered in red colubus monkeys in western Uganda.<sup>106</sup> Although how some of these new viruses, such as SFV and the new poxvirus, affect humans has yet to be determined, others have proved to be highly lethal in humans.

Emerging infections are coming from non-primate animals, too. The Ebola virus causes hemorrhagic fever and is one of the most lethal pathogens affecting humans. Depending on the viral strain, the death rate among those who contract Ebola varies from 50 to almost 90 percent.<sup>107</sup> Although human outbreaks of Ebola have been traced back to contact with chimpanzees and gorillas, the primary reservoir of the Ebola virus is suspected to be the fruit bat.<sup>108</sup> Other animals found to be infected with Ebola include forest antelopes, rodents and shrews in Central Africa.<sup>109</sup>

Taken together, these studies suggest that a considerable proportion of NHPs and other animals in Central Africa are infected with a wide range of viruses (including many that have yet to be detected) and that transmission of these viruses into the human population is significant and actively ongoing.<sup>110</sup> To make matters worse, HIV/AIDS is highly prevalent in Central Africa. The pandemic has left a large immunocompromised human population that is extremely susceptible to new infections.<sup>111</sup> A recent study found that among 191 HIV-infected people in Cameroon, 80 percent butchered wild animals, 84 percent consumed NHPs and more than 8 percent kept NHPs as pets.<sup>112</sup> Humans and all other animals are like nightclubs for viruses. In us, different viruses can exchange greetings, mingle and swap genes to create new viral strains. This hazard is elevated in those with pre-existing infectious diseases. In HIV-infected individuals, newly introduced viruses from other animals and circulating HIV can potentially recombine, creating new zoonoses that may be even deadlier.<sup>113</sup>

## **Other pathogens**

The recent emergence of zoonotic infections is not confined to Central Africa. The Nipah virus from Malaysia is one example. It shares similarities with another paramyxovirus: the Hendra virus. Hendra was identified in 1994 in Australia when two of three infected people died

after contact with horses suffering from a severe respiratory disease.<sup>114</sup> It is believed that the horses were infected by fruit bats. Of interest, however, is that there was no evidence of Hendra virus infection in a study of wildlife rehabilitators who frequently handled these bats.<sup>115</sup> This suggests that some intermediate host may have been required for the amplification in and/or adaptation of the virus to the bats.<sup>116</sup> Nipah and Hendra viruses may not be new. Phylogenetic studies suggest that they have been around for a long time but only caught our attention after ecological changes led to human contact with infected animals.<sup>117</sup>

SARS, which caused a near-pandemic and resulted in more than 8000 cases and 774 deaths, likely had its start in the bushmeat trade in the Guangdong Province in China and nearby regions.<sup>118</sup> Although thousands of civets—small arboreal mammals exploited for their musk-producing glands—were slaughtered en masse because they were suspected to be the source of the infection, SARS is now believed to have emerged from infected bats.<sup>119</sup> The bats were captured from the wild and traded for the live markets of China.

In addition to occurring throughout Southeast Asia, live markets are increasing in New York and California due to the growing Asian immigrant populations in both states.<sup>120</sup> Regardless of their location, these markets are miserable places for animals and provide an opportunity for the spread of diseases. Here, live animals of a wide variety of species sold for food are crammed into cages where they are unable to move, often causing those at the bottom to be crushed to death.<sup>121</sup> The animals are often deprived of food, water and shelter and are exposed to extreme heat or cold. The slaughtering methods used are also often extremely inhumane.<sup>122</sup> Turtles have their intestines removed while they are still alive and live birds are placed in plastic bags until they suffocate.<sup>123</sup> In Chinese markets, cats and dogs sold for food may be slowly bled to death or bludgeoned.<sup>124</sup> Hygiene in the markets is extremely poor, with the animals shedding copious amounts of feces, urine and other excretions.<sup>125</sup> These secretions may contain large numbers of pathogens that are potentially hazardous to humans. Because of the openness of these markets, newly introduced animals may come into direct contact with sales clerks and customers, in addition to the animal handlers and butchers.

After many studies examined how SARS appeared and spread within these markets, researchers now suspect that at some point in the wildlife supply chain, infected bats were brought into contact with susceptible hosts, such as civets, in whom the virus amplified.<sup>126</sup> The intermingling

of species established a cycle in which susceptible animals and humans could become infected. We may learn next that bats were not the primary source of SARS after all and that a yet-unidentified creature was involved—one that may have infected both the bats and the civets.<sup>127</sup>

Virologist Ron Fouchier of Erasmus MC University in the Netherlands says that regardless of whether or not bats were the primary source, it would be a mistake to wipe them out. The problem is not the bats, he says, but rather what humans do with them. People eat bat meat and use their feces in medicine, he says. 'Rather than blaming animals and killing them, we should change our behavior.'<sup>128</sup> After the SARS epidemics subsided, an editorial in the *American Journal of Public Health* made this observation: 'The concentration of animals, their overlapping sojourns in the markets (allowing disease to spread through vast numbers of animals), and their interactions with humans (facilitating human infection) make these markets ripe for zoonoses. Once an epidemic starts among animals, it can spread to animals reared in less cruel conditions.'<sup>129</sup>

Some of the pathogens that have emerged in the past few decades, such as Ebola, have remained largely confined to localized populations. However, as we ship animals regionally and across the globe, we risk dispersing zoonoses worldwide. The only time Ebola was known to have ever entered the USA was when infected NHPs were imported for biomedical research.<sup>130</sup> Populations participating in the bushmeat trade are increasingly connected with urban communities, which facilitate long-distance transport of bushmeat.<sup>131</sup> SARS became a near-worldwide pandemic, in part, because infected animals were probably shipped throughout Southeast Asia.<sup>132</sup> The Nipah virus could have remained confined to the Sungai Nipah New Village where it began. Instead, it spread throughout Malaysia and Singapore through the trucking of infected pigs.<sup>133</sup> The Marburg virus, a cousin of Ebola, is originally from Africa. Yet it was first detected in 1967 in the German town of Marburg after laboratory workers caught it from infected African green monkeys imported from Uganda.<sup>134</sup> In the USA, rabies was introduced to the mid-Atlantic states in the 1970s when raccoons captured from rabies-endemic areas were used to repopulate hunting pens.<sup>135</sup> As James Hughes, longtime director of the National Center for Infectious Diseases at the Centers for Disease Control and Prevention (CDC), quipped in 2003, 'People have looked very hard for the source in nature of Ebola virus, and they haven't found it . . . I certainly don't want to find it as the result of the importation of an infected animal.'<sup>136</sup>

## **A pathogen's ideal environment**

If viruses, bacteria and parasites could tell us about their ideal environments, we would hear them describing the animal trade among their top choices. We have seen a glimpse of what happens to animals once they reach their intended destination. But what occurs before and during transport is no less harmful and, as a result, these animals are highly prone to catching and transmitting infectious agents. The unfortunate reality is that few laws exist to protect animals from harm during any phase of the trade.<sup>137</sup> When regulations exist, they are rarely enforced or the penalties are so minor that they provide almost no deterrent.<sup>138</sup>

In fact, the paucity of regulations has spawned a massive underground, illegal wildlife trade in addition to the legal trade. The illegal trade is highly lucrative. In comparison with other illegally traded items, such as guns and drugs, animals are quite cheap to come by, the risks of penalties are drastically lower and the payoffs can be much greater.<sup>139</sup> For example, ground rhinoceros horn can earn higher profits than the equivalent in gold or cocaine.<sup>140</sup> After the smuggling of drugs, the illegal wildlife trade is the most valuable illegal commerce in the world—even more profitable than the smuggling of weapons or humans.<sup>141</sup> Like other illegal trades, the illegal wildlife trade has become an increasingly well-organized endeavor with worldwide criminal syndicates creating black markets and smuggling routes.<sup>142</sup> According to the US State Department, 2–5 million birds, including parrots, eagles and hummingbirds, as well as millions of reptiles and mammals, are smuggled worldwide annually.<sup>143</sup> However, accurate estimates are hard to come by because of the illicit nature of the trade. As is the case with the legal trade, the USA, Europe, China and other Asian countries are the greatest consumers of illegal wildlife.<sup>144</sup>

Regardless of whether the trade is legal or not, harsh capture techniques kill many animals before they are ever shipped anywhere.<sup>145</sup> For example, one-third of all captured birds from Tanzania and up to half of finches and waxbills captured in Senegal die before export.<sup>146</sup> During transport, animals are subjected to extreme stress. Virtually all international commercial trade of wildlife occurs by air. The International Air Transport Association has established only voluntary guidelines for shipping animals. Additionally, these are only enforceable for species listed under CITES. Even when CITES-listed species are involved, violators of the guidelines are usually merely given warnings or fined minimal penalties. Thus there is little incentive for wildlife traders to

follow the guidelines. To cut shipping costs, traders pack as many animals as possible into flimsy crates or cardboard boxes, sometimes taping the animals together or binding them to restrict their movements.<sup>147</sup> Animals at the bottom of the crates are often smothered and crushed to death.<sup>148</sup> Overcrowding, exposure to extreme temperatures, filthy conditions, poor diets, dehydration and disease are the norm.<sup>149</sup> As a result, a significant number of the animals (60–70 percent of reptiles and birds) die from the transport conditions alone.<sup>150</sup> The animals who do survive the shipping process are in such poor health that many of them die shortly after their arrival at their intended destinations. It is estimated that nine out of ten reptiles who survive shipment into the USA die within their first year of captivity and one in ten birds die within 30 days.<sup>151</sup>

Illegal traffickers are increasingly devising more ‘resourceful’ and harmful ways to smuggle animals across borders. To restrict their movement or keep them from crying out, animals are bound, gagged and even drugged into unconsciousness and then stuffed into all manners of items.<sup>152</sup> One investigator described how at a market in Ecuador he was offered a parakeet: ‘I asked the seller how I would get it on an airplane. “Give it vodka and put it in your pocket,” he said. “It will be quiet.”’<sup>153</sup> Hummingbirds have been found bound and stuffed into empty packs of cigarettes.<sup>154</sup> A US agent on the US–Mexico border found baby monkeys crammed into a car’s air conditioning ducts. Most of them died from suffocation. Animals have been smuggled stuffed into thermoses, stockings, toilet paper tubes and hair curlers.<sup>155</sup> As one Mexican Government wildlife expert reports, ‘For every 10 animals trafficked, only one survives.’<sup>156</sup>

Almost all of the same factors that cause animals in the trade distress and suffering also cause immunosuppression, leaving them extremely vulnerable to new infections. As a result, the trade creates very sick animals and conditions ideal for pathogens to multiply. Additionally, of all the determinants contributing to the emergence of zoonotic pathogens (such as ecological factors, natural selection and personal behavior), ‘species-jumping’ events that expand the range of viable hosts may be among the most important.<sup>157</sup> Holding different populations of animals, particularly sick animals, together during shipment or while housed at pet stores, zoos, circuses, laboratories, markets and hunting pens may result in new strains of pathogens that might not have occurred otherwise.<sup>158</sup> Karesh and Cook aptly summarized the zoonotic risk: ‘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 into the wild with new potential pathogens.<sup>159</sup>

### **One global infectious disease world**

In 1980 the World Health Organization (WHO) announced the global eradication of smallpox.<sup>160</sup> This is one of the most devastating human infectious diseases encountered and its eradication was a tremendous public health victory. We were able to eradicate smallpox in large part because the virus infects only humans and no other species serves as a reservoir. But, with the WHO announcement, we may be singing our victory song too soon. In 2003 an outbreak of monkeypox made headline news as it spread across half a dozen states in the Midwestern USA.<sup>161</sup> Epidemiologic investigations confirmed that the disease was introduced into the country when a shipment of infected African Gambian rats were sold to pet dealers, one of whom housed the rats with prairie dogs.<sup>162</sup> The prairie dogs subsequently contracted monkeypox, were then sold as pets and transmitted the infection to 71 people. 'Basically you factored out an ocean and half a continent by moving these animals around and ultimately juxtaposing them in a warehouse or a garage somewhere,' said Jeffrey Davis, chief medical officer and state epidemiologist for infectious diseases at the Wisconsin Division of Public Health.<sup>163</sup>

Monkeypox actually entered the USA for the first time in the 1950s, when several outbreaks occurred in NHPs shipped to laboratories.<sup>164</sup> Interestingly, it was not found in the source NHPs free-living in India and Southeast Asia, suggesting that the NHPs shipped to the USA became infected at some point during their transportation. Monkeypox virus is closely related to the smallpox virus but, thus far, it is not highly lethal in humans. However, with opportunities to jump between species and grab more genetic material, it could evolve into a new pathogen to be reckoned with, similar to smallpox. A far deadlier monkeypox strain than that shipped into the USA through Gambian rats causes a disease that is 'virtually indistinguishable' from typical smallpox, according to virologist Mark Buller of St Louis University.<sup>165</sup> About 10 percent of those affected by this Congo Basin strain die—a rate approximating the African death rate from smallpox. Worse yet, evidence suggests that monkeypox in the Congo Basin is evolving so that it could become easily transmissible from person to person.

Not all zoonotic infections are as media-grabbing as monkeypox. Nevertheless, they can pose significant health burdens and can put the most

vulnerable humans at risk from serious illness. In the USA, contact with pet reptiles causes frequent outbreaks of *Salmonella* infection.<sup>166</sup> Approximately 7 percent of all *Salmonella* infections and 11 percent of those among people younger than 21 years are caused by direct or indirect contact with reptiles—about 74,000 each year.<sup>167</sup> Although *Salmonella* usually causes a mild, self-limiting gastroenteritis, young children, the elderly and immunocompromised individuals are at risk of more severe diseases, including meningitis and sepsis, and death.<sup>168</sup> Young children are especially prone to infection from reptiles because of their frequent contact with them at petting zoos, fairs, flea markets and in homes. In 1975 the US Food and Drug Administration banned the import and sale of turtles of less than four inches in carapace size as pets (incidentally, there was no ban on exports).<sup>169</sup> This four-inch rule was intended as a guideline above which it would be difficult for children to put turtles in their mouths like toys. Despite this ban, however, annual outbreaks in the USA continue, in part due to limited enforcement of the ban, but also because a host of other reptiles and amphibians, whose sales are not restricted, are carriers of *Salmonella*.<sup>170</sup>

*Salmonella* infection in reptiles and amphibians tends to be asymptomatic (i.e. the animals don't show any symptoms) and quite common. Thus reptiles can shed *Salmonella* in their feces over prolonged periods of time with nearby humans being none the wiser. An analysis conducted in Germany and Austria of 48 reptile species found *Salmonella* in 54 percent of the sample.<sup>171</sup> Of these positive individuals, most came from pet stores. A study in Japan found that 74 percent of reptiles from pet stores carried *Salmonella*.<sup>172</sup> Although all reptiles may be carriers, several studies, as will be described later, suggest that *Salmonella* prevalence may be higher in captive reptiles than in free-living animals. Given that captivity can be stressful and that pet stores are notorious for inhumane and unhygienic conditions, it is reasonable to postulate that reptiles in such stores are more likely to carry and/or shed pathogens such as *Salmonella* than free-living animals.

Humans become infected not only by direct contact with reptiles and amphibians but also by contact with their environments, such as aquarium water.<sup>173</sup> In 1996 a *Salmonella* outbreak occurred among 65 children after they attended a Komodo dragon exhibit at a metropolitan zoo.<sup>174</sup> None of the infected children had touched the dragon but almost 83 percent had touched the wooden pen in which the animal was housed. Other *Salmonella* infections and outbreaks in the USA have occurred after indirect or direct contact with African dwarf frogs, boas,

iguanas and bearded dragons.<sup>175</sup> In Europe and elsewhere, reports of human *Salmonella* infections are paralleling the rise in importation of reptiles and amphibians.<sup>176</sup>

*Salmonella* is, of course, just one of many infections that have passed from wild animals to humans. NHPs carry herpes B virus, mongooses carry cowpox, parakeets carry *Chlamydia*, hedgehogs carry *Yersinia* and hamsters carry tularemia.<sup>177</sup> In one study, 17 out of 28 different species of squirrels, gerbils, mice and chipmunks purchased from trading companies in eight countries were found to be infected with *Bartonella* bacteria, including six novel bacteria species.<sup>178</sup> *Bartonella* can cause inflammation of the heart and the central nervous system and trench fever in humans. An outbreak of psittacosis, a parasitic infection that causes respiratory illness, occurred among people who purchased birds from nine US pet stores in 1995.<sup>179</sup>

Exposure to animals at circuses and zoos can also result in human infection. At an exotic animal farm in Illinois, 12 circus elephant handlers showed evidence of infection after 3 elephants died of tuberculosis.<sup>180</sup> A recent study found that *Blastocystis*, a parasite that causes gastrointestinal illness, is spreading among animals in zoos and transmission is occurring between animals and zookeepers.<sup>181</sup> Seven animal handlers tested positive for tuberculosis after an outbreak occurred among monkeys and rhinoceroses at a zoo in Louisiana.<sup>182</sup> As one study author attested, 'Zoos are indeed a hot spot for interspecies spread of infectious diseases.'<sup>183</sup> The same can probably be said for circuses and animal amusement parks. Between 1990 and 2000 in the USA, more than 25 outbreaks of human infectious diseases occurred due to animal exhibitions alone.<sup>184</sup>

Pavlin et al. looked at the types of mammals imported into the USA between 2000 and 2005 and assessed their potential to transmit 27 different zoonotic diseases.<sup>185</sup> The investigators found that the imported animals were capable of carrying a myriad of significant infectious agents and diseases, including Marburg virus, Ebola virus, herpes B virus, rabies, tuberculosis, avian influenza (H5N1), yellow fever, tularemia and anthrax. Thanks to the wildlife trade, we are unwittingly shipping many of these pathogens and diseases throughout the world. Michael Osterholm, director of the Center for Infectious Disease Research and Policy at the University of Minnesota, fittingly described the public health risks as a result of the trade when he stated, 'We now have this potential to make it literally one global infectious disease world.'<sup>186</sup>



## **Suburban monkeys and the loss of biodiversity**

We are creating a global infectious disease world in more ways than one. In addition to directly increasing our risk of epidemics, the wildlife trade is causing devastating destruction to our ecosystems and loss of biodiversity. As will be explored later, loss of biodiversity has already caused a rise in some very notable infectious diseases. Worldwide, approximately 1.8 million species of animals, plants, insects and other life forms have been identified.<sup>187</sup> But that is a very small number compared with how many we are not aware of. Estimates of the true number of species on earth range anywhere from 2 to 100 million (the majority being microbes). That's a wide range, but it shows us just how little we know about the spectrum of life on our planet. Sadly, if trends don't reverse, we will probably never know just how rich our earth's biodiversity is... or once was.

Almost universally, the fate of wildlife populations is grim. A massive extinction of animals is taking place.<sup>188</sup> At a recent UN conference in Nagoya, Japan, scientists pointed out that the earth is losing species at 100–1000 times the historical average.<sup>189</sup> According to the International Union for the Conservation of Nature Red List of threatened species, more than one-fifth of all the currently known vertebrate species are threatened today.<sup>190</sup> Over 100 species of amphibians are estimated to have become extinct since 1980 and of the remainder, one-third are under threat.<sup>191</sup> Almost 100,000 tigers existed worldwide about a century ago but today fewer than 3500–5000 may remain in the wild.<sup>192</sup> Of the 145 species of parrots in the Americas, almost one-third face extinction.<sup>193</sup> Our closest living relatives, the great apes, are on the brink of extinction. Almost half of the 634 species of NHPs may soon vanish.<sup>194</sup> More than 70 percent of Asian NHPs and more than 90 percent of NHPs in Vietnam and Cambodia are threatened.<sup>195</sup> Even previously threatened species, such as elephants, which due to conservation efforts were experiencing recovery, may now be at serious risk again.<sup>196</sup>

Eminent paleontologist Richard Leakey refers to the current biodiversity crisis as the sixth great extinction.<sup>197</sup> The last occurred 65 million years ago at the end of the Cretaceous period. It led to the fall of the dinosaurs and the ascendancy of humans and other mammals. Leakey estimates that yearly between 17,000 and 100,000 species vanish completely. 'For the sake of argument,' he says, 'let's assume the number is 50,000 a year. Whatever way you look at it, we're destroying the Earth at a rate comparable with the impact of a giant asteroid slamming

into the planet, or even a shower of vast heavenly bodies.<sup>198</sup> By Leakey's estimates, half of the world's species will become extinct within the next century and most biologists polled in the USA are convinced that a mass extinction of plants and animals is underway.<sup>199</sup> What makes the sixth extinction so unlike the five prior ones is that the cause is almost entirely human. And, unlike the last great extinction, this one is not likely to benefit us.

The human-derived causes of the loss of biodiversity are multifactorial. As the human population grows, so does the demand for land and other resources.<sup>200</sup> Perhaps the greatest threat to species survival is habitat loss.<sup>201</sup> Deforestation and other habitat loss is increasingly occurring due to the conversion of land for intensive livestock and agriculture, logging and to make room for the ever-increasing human population.<sup>202</sup> While habitat loss may be the main cause of extinction overall, the wildlife trade is also playing a major role, and for many species and in many regions of the world the wildlife trade is the most immediate threat to species' survival.<sup>203</sup> For example, in the Congo Basin, commercial hunting of wild animals for meat has already caused numerous local extinctions throughout the region.<sup>204</sup> According to Dr John Behler of the Wildlife Conservation Society, the trade for food and traditional medicine is causing the demise of turtle populations.<sup>205</sup> Some 50 parrot species are in jeopardy due to the exotic pet trade. Prior to the CITES ban on trade in ivory, the number of African elephants fell by half in ten years, and they were at risk again when both Tanzania and Zambia proposed re-opening the ivory trade.<sup>206</sup> Fortunately these bids, backed by China and Japan, were rejected by CITES in March 2010. The wildlife trade and habitat destruction are the biggest threats to NHPs.<sup>207</sup> In all, the wildlife trade threatens about one-third of all mammals and birds.<sup>208</sup>

The trade in wildlife continues even as species diminish in number. In fact, the more rare the species, the greater the public demand and economic incentive. This creates a positive feedback loop that leads to even greater exploitation.<sup>209</sup> Additionally, as a species in one area is exploited to extinction or near-extinction, traders just either move to other regions or broaden their repertoire to include other species in a never-ending cycle. Vincent Nijman of Oxford Brookes University describes this cycle: 'we see species that are in fashion traded in great numbers until they are wiped out and people can't get them anymore. So another comes in, and then that is wiped out, and then another comes in.'<sup>210</sup>

By removing animals, we risk serious repercussions for the entire local environment.<sup>211</sup> The collecting of animals itself often destroys habitat. For example, trees are commonly felled to capture wild

birds, diminishing nesting sites for future generations.<sup>212</sup> Burrows are destroyed to capture snakes and tortoises, again destroying habitats for future generations.<sup>213</sup> Forests and other habitats are burned down to 'out' the targeted animals.<sup>214</sup> Toxins and chemicals, such as gasoline, are used to drive reptiles from their homes. In addition to harming the species captured, the wildlife trade causes a cascade of events that disrupts ecosystems and threatens the survival of other species that are not even part of the trade.

Each species plays an important ecological role in its natural environment.<sup>215</sup> Many of those threatened serve as vital seed-dispersal agents and their removal or diminishment threatens the very survival and diversity of our most ecologically important forests and other ecosystems.<sup>216</sup> The trade removes animals serving as important food sources for other animals.<sup>217</sup> Alternatively, removal of many of the large predators impedes the keeping of other populations in balance.<sup>218</sup> In essence, the loss of a single species can have far-reaching effects and can disrupt the ecological balance of an entire forest.<sup>219</sup>

As if removing ecologically vital species is not enough, the trade is causing another serious worldwide problem that further exacerbates the biodiversity crisis: the introduction of non-native animals that endangers native species.<sup>220</sup> Non-native species are released accidentally, escape or are released intentionally by people who are no longer able, or want, to care for them.<sup>221</sup> Intentional release frequently occurs when people purchase young animals only to find that they grow into an unmanageable size. The introduction of non-native animals threatens native species by competing for resources and habitats, by preying on native species for food and by altering native ecosystems.<sup>222</sup> In Florida, a major importing site in the USA, non-native squirrel monkeys, macaque monkeys, Burmese pythons, South American parrots, African Nile lizards and other exotic animals have established themselves in the Everglades and are now commonly seen roaming neighborhoods.<sup>223</sup> Florida residents are now looking out of the doors of their nice suburban homes and seeing African monkeys for the first time swinging through the trees and rummaging through their trash cans!

In addition to introducing non-native species, the trade in wildlife introduces infectious diseases to new populations.<sup>224</sup> One of the biggest threats to a large number of amphibians is the disease caused by a chytrid fungus, which is believed to have originated in South America and is wiping out whole populations across the globe. It was facilitated by the wildlife trade and its consequent release of non-native species carrying the fungus.<sup>225</sup> Ranaviral disease of amphibians is also believed

to be globally spread via the wildlife trade.<sup>226</sup> As we help spread diseases to other species, we also risk a spill-back effect, in which the zoonotic pathogens come back to infect us.<sup>227</sup>

Independently, the wildlife trade is creating what conservationists have dubbed the 'empty forest syndrome'.<sup>228</sup> Progressively, forests and other natural habitats are being emptied of wildlife. Confronted by the combination of habitat loss and fragmentation, climate change, pollution and the wildlife trade, animals are experiencing an assault of alarming magnitude. Magnifying this attack, a significant number of animals involved in the wildlife trade are taken from biodiversity 'hot spots', the ecologically richest and most species-diverse places on earth.<sup>229</sup> Many of these hot spots are crucial carbon sinks and their destruction exacerbates global warming, further perpetuating the cycle of biodiversity loss.<sup>230</sup> As an agent of the US Fish and Wildlife Service stated, 'people don't realize when they buy an exotic pet they are taking the rain forest and putting it in a coffin'.<sup>231</sup> Regardless of whether we are taking wild animals for pets, food or other purposes, we are devastating our ecosystems.

### **The human impact of biodiversity loss**

Not only is this biodiversity loss bad for ecosystems, it's also bad for us. Evidence suggests that the greater the diversity of species, the less the chance that humans will contract zoonotic pathogens. Although it might be intuitive to think that greater diversity of species also means greater opportunities for infectious agents to enter the human population, evidence is suggesting that the opposite may be true. Ostfeld describes several mechanisms by which high biodiversity can buffer against the transmission of pathogens, including the following:

1. Greater species diversity reduces the population of an important natural reservoir (such as an animal species) for pathogens.
2. Greater diversity reduces the population density of pathogen-carrying vectors (e.g. insects).
3. Greater diversity reduces the encounter rates between vectors and reservoirs.<sup>232</sup>

In summary, the greater the diversity in an ecosystem, the less the chance of one reservoir species becoming dominant and, in many cases, the less the chance that humans will encounter a pathogen-carrying vector.

An understanding of the transmission of the pathogen that causes Lyme disease illustrates how species diversity affects a natural reservoir or vector of an infectious agent. A reservoir serves as a host on which an infectious agent depends to survive or multiply, but usually does not actually get sick from the infectious agent or can carry the infectious agent for a long time before getting sick. A vector transmits the infectious agent from the host to another animal, who does get sick. In the case of Lyme disease, an illness caused by the bacterium *Borrelia burgdorferi*, white-footed mice, short-tailed shrews and eastern chipmunks serve as important reservoirs. In the mouse, for example, the bacteria can find a hospitable environment in which to grow and multiply. The vector here is a tick of the genus *Ixodes*, one of which is commonly referred to as the 'deer tick'. A tick contracts *Borrelia* after it feeds off a white-footed mouse carrying the bacteria; the tick then transmits the bacteria to humans (and other animals) when it feeds off them.

The greater the biodiversity in a North American forest, the more competition white-footed mice have for survival and the less likely they are to dominate the forest. Forests with high diversity will include the white footed-mouse, but also a large number of other animals in whom the bacteria don't live and multiply so readily, but who are equally good sources of food for ticks. Thus, the greater the number of uninfected animals, the fewer encounters ticks will have with infected (reservoir) animals and the less likely ticks will carry the bacteria. Therefore, this reduces our risk of encountering a tick carrying the *Borrelia* bacterium. Ostfeld refers to the phenomenon by which high biodiversity reduces infection risk as the 'dilution effect'.<sup>233</sup>

In the USA and elsewhere, Lyme disease is on the rise. The CDC estimates that with approximately 20,000 new cases reported each year, Lyme disease is the most common vector-borne disease in the USA, and the annual rate of reports has more than doubled since 1991.<sup>234</sup> If not caught and treated in time with appropriate antibiotics, Lyme disease can result in serious cardiac and neurological repercussions, including chronic pain and numbness, paralysis and visual problems.

In the northeastern USA, we have extensively fragmented our forests (a euphemism for 'suburbanized'), resulting in biodiversity loss and unfettered population growth of small animal reservoirs of Lyme disease—those animals who are better able to adapt to the sparse forest patches than other mammals.<sup>235</sup> Based on the dilution effect theory, Ostfeld and Keesing hypothesized that human Lyme disease incidence rates would be lower near habitats containing greater diversity.<sup>236</sup> After analyzing state and multistate regions in the USA, they found a

significant negative correlation between the species richness of small land mammals and reports of Lyme disease. Hence, the greater the species diversity, the fewer the number of cases.

The dilution effect has been supported by studies of other formidable infectious diseases, including West Nile virus illness, hemorrhagic fevers, leishmaniasis, African trypanosomiasis, Chagas disease and Rocky Mountain spotted fever.<sup>237</sup> Of course, there may be cases when biodiversity loss in fact causes the very reservoirs or vectors of certain pathogens to be reduced, thus decreasing our risk of those infections.<sup>238</sup> This will require further investigation. Regardless, there is ample evidence to suggest that some very serious infectious diseases today are becoming greater threats, in part due to reductions in species diversity.

### **Are we just crying wolf?**

Alarmists can be rather irritating. Either they cry wolf when there is none, or they are right—and thus are even more annoying! No one likes to hear the bad news, but we are truly endangering ourselves if we ignore the disturbing realities of the wildlife trade and don't take action against it. In order to minimize the threat of this trade, we have to ensure that we choose actions that will be effective. It might seem that all that's really needed to prevent the animal trade from causing infectious disease havoc is simply to monitor the shipment of animals. However, given the immense numbers imported annually to each nation, it is almost impossible for border officers to reliably track them. As Gerson et al. stated in their review of inspections in Canada, 'more than 12 million commercial shipments are imported... annually, and only about 2% of these are physically inspected'.<sup>239</sup> In the USA, with fewer than 100 inspectors monitoring nationwide imports, they would have approximately three seconds to inspect each animal if that's all they did every minute of every work day.<sup>240</sup> Even if we were to drastically increase shipment inspections, simple inspections would still not detect pathogens if, as is commonly the case with *Salmonella* and other pathogens, the animals carrying them showed no overt signs of illness.

Additionally, much of the wildlife trade occurs domestically, from region to region within a nation, leaving little to no paper trail and minimal opportunity for inspection.<sup>241</sup> To supply the US pet trade, an estimated 3–5 million reptiles and amphibians are captured from the wild in the state of Louisiana alone.<sup>242</sup> So monitoring of shipments is not in itself a viable solution. Other options offered to prevent the trade

from spreading exotic infectious diseases include screening of animals with laboratory tests, pre-emptive treatment for known diseases, and quarantine of animals.<sup>243</sup> As a report by the CDC stated,

Many of these solutions are not feasible or practical to use on the large volume of animals that are being imported and cannot be employed to prevent new or emerging pathogens or infections. Ultimately, import restrictions may be the only means of preventing introduction of exotic infections.<sup>244</sup>

Breeding wild animals for the commercial trade is now a common practice, partly because of an implicit assumption that it will ease the risk of infectious diseases, prevent the destruction of ecosystems and preserve species. But does breeding do all of this? Many reptiles supplied for the trade in the USA are bred, but they still cause *Salmonella* outbreaks year after year.<sup>245</sup> In the USA, the Wild Bird Conservation Act of 1992 outlawed the import of most wild-caught birds.<sup>246</sup> As a result, most birds purchased at pet stores in the USA are bred in captivity, but they still transmit psittacosis, which can cause a serious pneumonia, to humans.<sup>247</sup> In a study of birds sold at nine different pet stores in Atlanta, more than one in ten people who bought them contracted chlamydiosis and suffered acute respiratory illness.<sup>248</sup> A breeder in Oklahoma supplied the pet stores. Captive-bred NHPs naturally carry herpes B virus, which can cause a deadly inflammation of the spinal cord and brain (encephalomyelitis) in humans.<sup>249</sup>

Breeding farms may actually increase levels of certain infectious diseases. According to the CDC, small turtles sold as pets in the USA frequently come from breeding farms, where the animals are housed in crowded ponds and nesting areas in a way that promotes *Salmonella* transmission.<sup>250</sup> Even though attempts are made to treat turtles, turtle eggs and turtle breeding ponds with antibiotics and other methods, the continual shedding of *Salmonella* by many turtles may be, as the CDC declares, 'stress related'. Several studies of turtle farms report a high prevalence of *Salmonella*.<sup>251</sup> Even more troubling is that the use of antibiotics to prevent *Salmonella* infections in animals is leading to antibiotic-resistant strains. One study of breeding farms in Louisiana, which routinely employ antibiotics, reported the presence of gentamicin-resistant *Salmonella* strains.<sup>252</sup> Other studies have found multiple pathogens resistant to antibiotics on wildlife breeding farms.<sup>253</sup> In contrast, many studies have found that *Salmonella* prevalence is much lower in free-living reptiles in comparison with

captive-bred and pet reptiles.<sup>254</sup> The investigators conducting these studies suggest that the stress of captivity renders animals more vulnerable to infection.

Investigators from veterinary schools in Pennsylvania and North Carolina did not detect *Salmonella* in any of the free-living turtles they sampled.<sup>255</sup> Like the CDC, these investigators postulated that 'captive reptiles may be crowded or subjected to poor hygienic protocol', thus increasing their risk of carrying and shedding *Salmonella*. Most recently, a California breeder of African dwarf frogs has been identified as the source of a *Salmonella* outbreak that caused sickness in more than 200 people in the USA.<sup>256</sup> In Chapter 4, we will explore how zoonotic pathogens flourish in intensive farms breeding and housing animals for food. Besides not necessarily being a more humane solution for individual animals, breeding and keeping animals in captivity is not only no guarantee against infections but may actually increase our risk.

Rather than taking the pressure off species, breeding animals appears to stimulate the trade in endangered species. First, many animals don't breed well in captivity or their breeding is cost-prohibitive.<sup>257</sup> Raising a farmed tiger to maturity, for example, is 250 times as expensive as poaching a wild tiger in India.<sup>258</sup> Second, breeding farms are frequently stocked with wild animals.<sup>259</sup> For example, turtle farms in the USA are stocked by capturing adults and eggs from the wild.<sup>260</sup> Indeed, several investigators found that the primary purchasers of wild-caught turtles are turtle farms, suggesting that they are a major threat to wild turtle populations.<sup>261</sup> Third, among those who purchase animals for traditional medicines, ornamentation or food, the majority prefer animals from the wild over farmed animals as the former are considered 'purer'.<sup>262</sup> Thus the trade of captive-bred animals would likely serve as a cover for the trade of wild-caught animals since it is almost impossible for trade agents to distinguish between the two.<sup>263</sup> Fourth, increased farming of exotic animals could also increase the demand for endangered species, spurring the illegal trade.<sup>264</sup> The legal trade, whether of farmed or wild-caught animals, appears to act as a stimulant to the underground trade.

As long as the trade continues—regardless of whether it is legal or illegal, or involves captive-bred or wild-caught animals—it will be problematic. It will threaten ecosystems and species survivability. It will cause immense suffering in animals, and risk human injuries and the worldwide spread of known and novel infectious diseases.

Additionally, some of our most vital medicines, including chemotherapeutic agents, come from the forests. With the destruction of ecosystems, we may lose some of our greatest medical treatments before they



are even discovered. The wildlife trade may also play a role in crimes against humanity. The Janjaweed, the militia that has carried out genocidal attacks in Darfur, for example, is slaughtering elephants by the hundreds to earn easy money from the illegal ivory trade.<sup>265</sup> Exotic animals and their body parts have become the new blood diamonds. The illegal animal trade goes hand in hand with transnational crime, including trade in ammunition and narcotics, and the trafficking of people.<sup>266</sup> Terrorist groups may also be engaged in wildlife smuggling to buy ammunition and provide financial support for their activities.<sup>267</sup>

The animal trade is now a major chink in the public health armor. Through the wildlife trade, terrorists could spread a bioterrorist agent or disease, such as anthrax, Ebola or the plague, around the globe in less than 48 hours, without ever having to leave their sitting rooms. As one expert stated when discussing the 2003 monkeypox outbreaks in the USA, 'It was probably easier for a Gambian rat to get into the United States than a Gambian.'<sup>268</sup> Ultimately, such bioterrorist attacks may just end up being the stuff of great thriller novels, but we don't need terrorist groups to threaten us—Mother nature is able to do that all by herself. According to microbiologist Dorothy Crawford, 'microbes are always going to be one step ahead of us. Their generation time is 24 hours, ours is 30 years.'<sup>269</sup>

The wildlife trade will be extremely difficult to eradicate because it is so lucrative and will require cooperation from nations across the world. However, we can take steps to help minimize it. Educating policy makers and the public through media campaigns about the dangers of the trade and the risk of infectious diseases from exotic animals are good steps. We can go further and advocate, in partnership with humane and wildlife protection organizations, for greater restrictions and bans on breeding farms and importation of wildlife. We can, together, also endorse greater enforcement of existing laws and increased fines and penalties. Offering alternative means of sustenance and economic development for impoverished people, such as bushmeat hunters, will help them not only in the immediate future but also further down the road. As wild animal populations become more and more diminished, the livelihood of bushmeat hunters will be threatened.<sup>270</sup> We can help prevent this by fostering the development of more sustainable activities, such as those that take advantage of the rich diversity of their wildlife as a means to entice tourists.<sup>271</sup> Ecotourism has taken off in many parts of the world and, where implemented appropriately to ensure wildlife protection and local participation, is proving rather successful economically.<sup>272</sup> Such activities encourage local populations

to help protect their wildlife and provide a more stable source of income.<sup>273</sup>

Ultimately, our greatest power may lie in educating and persuading the public not to buy in to the trade. The trade would not exist if there were not a ready supply of consumers. Educating the public about the health risks and the animal suffering associated with the keeping of exotic animals as pets, entertainment venues using animals, the skin and fur trade, and so on can be a powerful deterrent. Parents will be less likely to take their children to animal circuses and petting zoos if they are aware of the potential health risks posed to their children. We can promote alternative and fantastic sources of entertainment, such as the Cirque de Soleil, which involves no animals in any of its circus shows. Other activities that foster an appreciation of wildlife without causing harm to them include outdoor hiking, animal 'watching', visiting animal sanctuaries and exploring local botanical gardens and their exhibits. The more steps we take to minimize the trade, the greater the chance we have to protect our own health and protect animals from so much harm. As Nathan Wolfe explained, 'Today HIV is so pervasive that it is hard to imagine the world without it. But a global pandemic was not inevitable.'<sup>274</sup> It's too late to prevent HIV, but perhaps we can prevent the next pandemic.