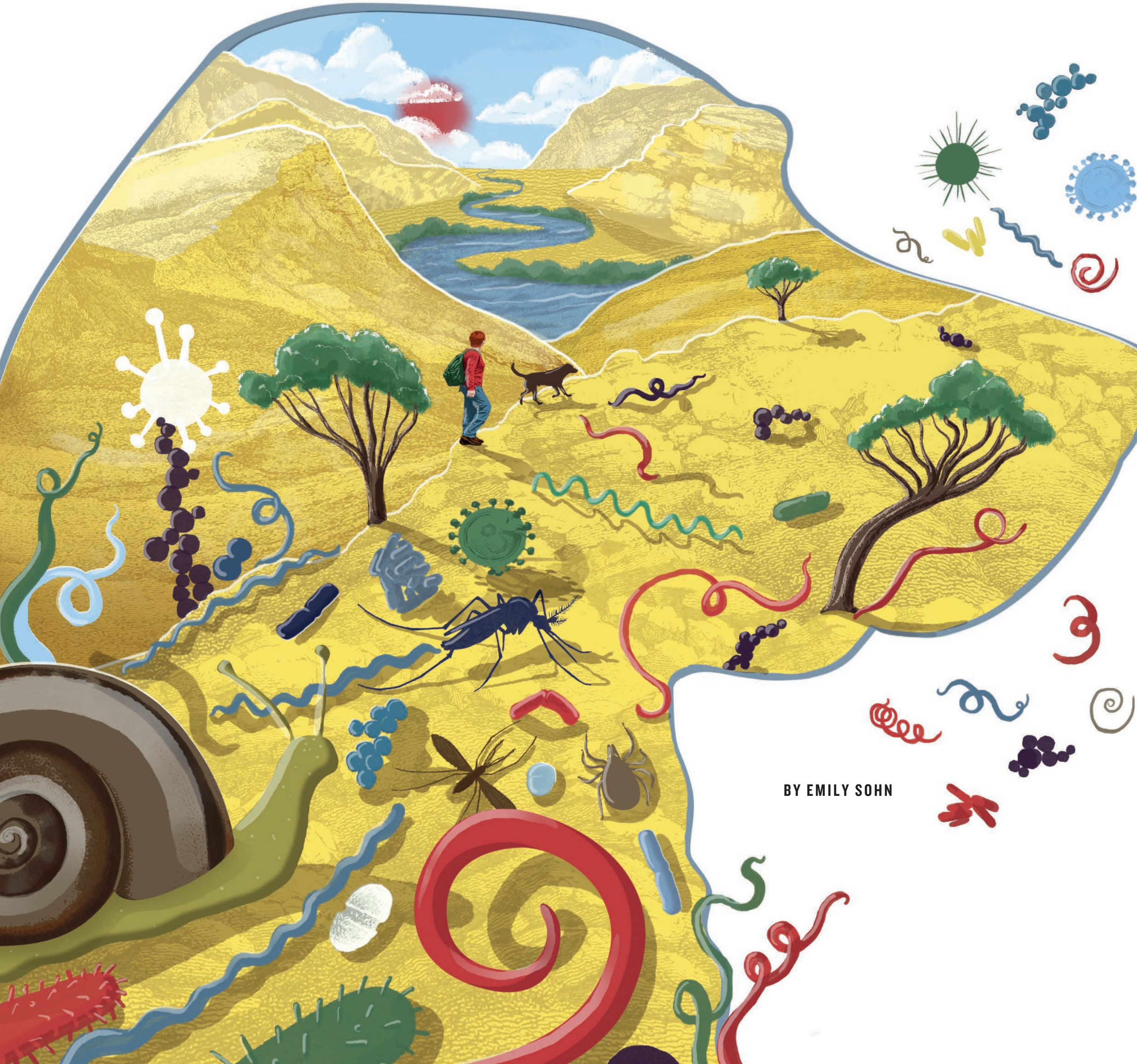
HOTHOUSE OF DISEASE

Dogs and cats in temperate regions are encountering pathogens that once thrived only in the tropics. As the climate warms and pests migrate north, animals, and some humans, are facing new health risks.



BY EMILY SOHN

In 2009, a one-year-old Weimaraner arrived at the University of Glasgow's Small Animal Hospital in Scotland. The dog was lethargic, with bleeding in the whites of its eyes and a lump on its right shoulder. A full assessment revealed an unexpected diagnosis: *Angiostrongylus vasorum*, a parasite that had never been reported in a dog in Scotland before.

Known to veterinary surgeons as both lungworm and French heartworm, *A. vasorum* infects dogs that eat parasite-carrying snails and slugs. The parasite had long been confined to warmer regions much further south, and to mainland Europe. But the Weimaraner had not travelled outside of Scotland; the parasite's appearance here was evidence that it was spreading northward[1]. And climate change seemed to be a probable cause — average temperatures in the country have risen by more than 1 °C over the previous four decades.

The Weimaraner case was a harbinger of what was to come. Since 2009, evidence of the parasite's spread has been found in molluscs and in foxes, which are also susceptible to the infection. One analysis found the parasite in 11% of the slugs and snails tested in a park near the home of the sick Weimaraner[2]. And a 2015 study found *A. vasorum* in more than 7% of foxes tested in northern England and Scotland, up from zero in 2005–06 (ref. 3). In southeast England, the proportion of infected foxes had more than doubled to 50% over an eight-year period. Scientists don't have enough data to calculate changes in the rate of *A. vasorum* infection among dogs, but in recent years, the disease has started to appear in dogs and foxes in places such as Sweden and Germany, and parts of the United States.

And it's not just *A. vasorum* taking advantage of the warming global climate; many other parasites and disease vectors are expanding into new territory. Although most research has focused on diseases of people and wildlife, the health of dogs and cats is now emerging as an area of concern. The pet-disease watch list includes infections spread by the growing populations of mosquitoes, ticks, sandflies and fleas, such as heartworm, lungworm, Lyme disease and leishmaniasis. Understanding how patterns of disease are changing among pets could open a window onto which pathogens might show up in new regions. This will help owners and vets to better prevent, recognize and treat outbreaks.

Human health may also benefit from a closer look at how pathogens are moving through animals, both house pets and those that live outside. Many of the same vector-borne diseases afflict both animals and people, so pets can act as sentinels for threats to human health. And as research accumulates about the changing pattern of pet and human diseases, the same debates are likely to come up. "Pets are kind of mini-me versions of humans," says Richard Ostfeld, an ecologist at the Cary Institute of Ecosystem Studies in Millbrook, New York.

In both cases, attempts to draw direct lines between climate and health only highlight the tangled relationship of the two — from the often-stuttering way in which climate change occurs to the complex interactions between parasites and their hosts. "Climate is undoubtedly a factor," says Eric Morgan, a veterinary parasitologist at the University of Bristol, UK. "But it's not the whole story, for sure."

ENABLING VECTOR SPREAD

For more than a decade, scientists have been determining the potential for climate change to alter the spread of infectious diseases. Although many of the details remain controversial, in a large number of cases, climate change does seem to be a factor. In humans, diseases such as malaria, cholera and dengue have spread to places where average temperatures have risen. And in wildlife, outbreaks of avian malaria, coral disease and chytridiomycosis, a fungal disease that kills amphibians, correlate with warming.

When it comes to companion animals, Morgan says, some of the closest scrutiny has been on heartworm (*Dirofilaria immitis*), a mosquito-transmitted parasite that infects dogs and cats. In Europe, heartworm was once confined to countries in the south, but, since the mid-1980s, it has expanded north to countries such as Hungary, Switzerland, Romania and Poland. And among other vectors of human and animal diseases, tick populations in Europe have expanded widely, not just northwards, but also into higher elevations.

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The effects of climate, however, are closely intertwined with other environmental influences, says Donato Traversa, a veterinary parasitologist at the University of Teramo in Italy, who has documented the recent changes in heartworm and lungworm incidence among cats and dogs. The complex interaction of factors is particularly well illustrated by an assessment of disease in pets rescued after Hurricane Katrina, which struck the southeast United States in 2005, says Traversa. After the devastating storm (which may well have been particularly severe because of climate change), mosquitoes flourished in flooded areas. Meanwhile, many dogs and cats lost their homes, Traversa says, causing them to spend more time outdoors, where they were vulnerable to the enlarged mosquito population. In the months that followed, thousands of animals were placed in shelters, and later many pets moved with their owners or to adoption centres elsewhere in North America. Among 414 dogs and 56 cats rescued from the Gulf Coast region up to 4 months after the hurricane[4], most had been infected with at least one disease, and many had signs of multiple illnesses, including heartworm, West Nile virus and bartonellosis. Many were present before the storm, but the subsequent dispersal of rescue animals risked the transmission of diseases to regions of the country where vets might not think to test for them.

In Europe, heartworm got a boost from the spread of the Asian tiger mosquito (*Aedes albopictus*), which arrived on the continent in 1979. And *A. vasorum* got a foothold when the European fox population grew as a result of a campaign against rabies. Human development that encroaches into rural habitats, and a substantial urban fox population, exposes pets to fox parasites.

So although climate may create the right conditions for a disease to spread, it is often other circumstances that help the disease to emerge in the first place. "You have the chance that something will arrive, multiplied by the chance it will establish if it arrives," Morgan says. "It's hard to separate the two."

MIXED MESSAGES

To disentangle the role that climate has in disease transmission, scientists are creating maps and models to understand what makes certain diseases take off and to refine predictions about where a disease might show up next.

Some relationships are already well understood. Warmer water, for example, means that mosquito larvae develop more quickly and emerge as smaller adults that need to feed more often to produce eggs, says John Trumble, an entomologist at the University of California, Riverside. More-frequent blood feeding means more opportunities

SAM FALCONER

JIM SCHEMEL/GETTY

Mosquitoes can transmit parasites that infect pets such as cats.

to transmit diseases, including malaria in people, heartworm in dogs and cats, and encephalitis in horses. Warm-enough temperatures also allow mosquitoes to become infectious all year round, Trumble says. This has already happened in Texas and other parts of the southern United States, and may eventually occur elsewhere.

Ticks also benefit from warm and humid conditions, which facilitate their survival, development and reproduction. Climate-based models predict that their range will expand even further and that the diseases they spread will have an earlier onset each year. But tick-borne diseases are influenced by effects other than climate, Ostfeld says.

In the northeastern United States, for example, forest fragmentation has been detrimental to predators of rodents such as the white-footed mouse (*Peromyscus leucopus*), which is a host for ticks[5]. Mice have proliferated at the same time as suburban sprawl has brought people closer to their habitat — and to disease-bearing ticks. “You are not only chopping up forests and increasing infected ticks. You are also plunking houses down right into infected areas,” Ostfeld says. Climate models, in other words, don’t tell the whole story. “Yes, there is fairly good evidence for a role for climate change, but it would be unfortunate if that were the only emphasized environmental change in a deeper story.”

“CLIMATE IS UNDOUBTEDLY A FACTOR. BUT IT IS NOT THE WHOLE STORY, FOR SURE.”

Scientists can’t conduct controlled climate experiments with multiple Earths in all their complexity, so models and lab experiments have to employ simplifying assumptions, Ostfeld says.

When it gets hot, for example, insects often seek shade. And, a warmer climate doesn’t universally translate into more disease, says Jason Rohr, an integrative biologist at the University of South Florida in Tampa. Each pathogen, vector and host has its ideal temperature range. And they all have limits: very hot temperatures can make mosquitoes less active, for example, or make conditions too dry for snails. Relationships between pathogens and hosts can also vary as the climate changes.

Rohr and his colleagues are trying to sort these relationships out by sifting through data from about 500 published papers to construct ‘thermal performance curves’ — which illustrate how an organism responds to variation in temperature — for 300–400 parasites and vectors, including viruses, bacteria, worms, protozoa and insects.

Better data could help scientists to make more accurate predictions about how diseases will respond to various climate scenarios and whether it’s possible to make generalizations across categories of diseases or between one region and another. There are 21 species of lungworm across the globe, Morgan points out. Will they respond in the same way everywhere?

Rohr’s work demonstrates the potential for wide variation. Amphibian outbreaks of chytridiomycosis, for example, which is caused by the fungus *Batrachochytrium dendrobatidis*, tend to occur when cold-adapted species of amphibian experience hot spells and when warm-adapted species experience cold spells[6]. In general, Rohr suspects that pathogens may be more tolerant of climate change than their hosts are, a finding that has relevance beyond frogs and salamanders.

More information will also help scientists to monitor whether some diseases become less common near the equator as their reach expands toward the poles. So far, Rohr says, there have been no documented cases of this shift.

“What I suspect will become more apparent in the next couple of decades is that the difference in thermal performance of the pathogen relative to the host is what is most important,” he says. “Not all host–parasite interactions are going to experience the same sort of effects of climate change.”

KNOWLEDGE INFORMS ACTION

Many scientists say that climate change must be looked at in a broader context. The world is changing. People and pets are moving around more than they used to, often carrying diseases to places where animals might not have any immunity. Researchers are also better at looking for diseases that may have previously gone undetected in certain populations, says Traversa, who urges caution in blaming climate for every new disease trend.

For pet owners and vets, research on the links between health and climate, along with other changes in the environment, could help to guide decisions about which diseases to vaccinate against or consider as potential diagnoses. Knowing what to watch for could make major dents in battling disease, says Morgan.

Scientists may draw on what they know about animals beyond the realm of pets. Morgan points to a disease called fly strike, for example, which sheep get when blowflies lay their eggs in the animal’s dirty fleece. In the United Kingdom, fly strike usually starts to appear in the spring, when temperatures are warm enough for the fly’s larvae to develop. As the onset of spring has shifted earlier, cases of the disease have also started to appear sooner. But it turns out there could be a simple solution, Morgan says: shearing sheep earlier greatly reduces fly strike.

“When you’ve got all these interacting factors, if you can pick out one and change it easily, then even large effects of climate change on the parasite can be annulled by simple management,” Morgan says. “If we understand the interaction, then perhaps we can do something about it.” ■

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