Andrew Dobson

A warmer world will be a sicker world

Aedes aegypti mosquito

In its report released on 6 April on *Impacts, Adaptation and Vulnerabilities*, the Intergovernmental Panel on Climate Change (IPCC) predicts that 20–30% of species will become extinct if the mean global temperature rises by more than 1.5–2.5°C this century. The IPCC similarly predicts that these higher temperatures will cause a considerable shift in the range of species and increase the burden from infectious diseases.

Andrew Dobson is an ecological parasitologist in the Department of Ecology and Evolutionary Biology at Princeton University in the USA. He argues that, in a world where climate change may allow vector-transmitted diseases to extend their geographical range, it may be sensible to conserve biological diversity for the purely selfish reason of protecting human health.

In 2002, you co-authored an article in *Science* describing the increase in climate-sensitive outbreaks of disease. What factors are favouring these outbreaks?

Even slight increases in moisture and temperature stimulate bacteria, fungi, viruses and the insects that are vectors of infectious disease. This is because longer, warmer summers enable pathogens to extend their range. Similarly, milder winters are not cold enough to reduce the number of pathogens and insect vectors. This means that it is not only going to be a warmer world, it is going to be a sicker world.

We are seeing disease outbreaks sensitive to climate in corals and oysters and, on land, in plants, animals, birds and humans. Some species even share certain diseases. Humans and animals – such as cattle and goats – are both susceptible to malaria for instance and there are many forms of avian malaria. Take the example of honeycreepers, which are forest songbirds that evolved only in Hawaii (USA). They are being decimated by malaria from mosquitoes that have been able to range higher in elevation due to warmer temperatures. Today, there are no native birds below 1500 m. In the 1960s, mosquitoes were restricted to elevations below 762 m.

The mosquito vector of malaria can survive as long as temperatures do not regularly fall below 16°C; in recent years, human cases have been reported in southern Europe, the Korean peninsula and the former Soviet Union.

Another worrying trend is that vectors of disease are becoming more virulent. The *Aedes* mosquito, which transmits the Dengue virus, is biting at a faster rate because of the warmer temperatures and therefore infecting more humans. In the first two months of this year, Brazil reported 85 000 cases of dengue fever, nearly 30% more than for the same period in 2006; half of these cases concerned a state bordering on Bolivia and Paraguay. In March, Uruguay confirmed the country's first domestic case of dengue fever in 90 years.

So 'tropical' diseases will migrate to higher latitudes, as these become warmer and more humid?

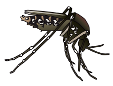
I think it likely that vector-transmitted pathogens will move into higher latitudes. The classic example of this is the ongoing epidemic of Bluetongue virus in European sheep. Until very recently, Bluetongue was restricted to Africa; it then moved across the Mediterranean at multiple locations and by colonizing new vector species (within the same genera of midges) was able to spread into southern Europe and as far north as the Netherlands.

The worrying thing here is that the range change was predictable by climate models; the ability to switch vectors was not predicted, however, and it was this that allowed the pathogen to spread much further north than predicted by climate models.

The key message here is, we should be more worried than we are about what we can predict using climate models and *very* worried about the unexpected!

Andrew Dobson with a baby tapir in the Peruvian Amazon

photo: Peter Hudson



Culex pipiens mosquito

What can we do to combat the spread of infectious diseases?

High biodiversity manages to buffer some of the negative effects of infectious diseases at present but, as we convert habitats for agriculture, or with urbanization, even as we improve human access to food and infrastructure, we may be reducing the ability of natural systems to buffer disease.

As infectious diseases move from tropical zones into temperate ones, the latter may find themselves harder hit than the tropics.

Why would the temperate zones be harder hit?

There is a greater biodiversity of species in tropical zones and thus a good chance that a mosquito will bite a species in which the disease doesn't develop. In temperate zones though, biodiversity is lower, so vectors have fewer options about what to bite. This means that any pathogen which manages to spread from the tropics to the temperate zone in a warmer world is likely to have a bigger impact, as it can focus on a few common and abundant susceptible species…particularly humans and domestic livestock which are increasingly the most common species!

The West Nile Virus is causing concern in the USA. It is carried by *Culex pipiens*, a mosquito which thrives in hot, dry climates in Africa, the Middle East, India and Europe. In 1999, the virus turned up in the USA for the first time, where it infected 62 people in New York, killing 7. During the next hot, dry summer in 2002, it infected 9000 people in 44 states and cases were even reported in Canada.

Generally speaking, will things get worse?

I suspect that things will get worse for two reasons. Firstly, climate change will have its most significant impact along the margins of habitats – the edges of deserts, the edges of cultivation on mountains. Climate change will allow some vector-transmitted pathogens to establish in these regions where they will increase the disease burden in populations of humans and domestic livestock with only low levels of immunity to these pathogens due to restricted prior exposure.

Secondly, other species may buffer this impact, as infected insect vectors that bite a non-viable host for the pathogen are essentially lost from the epidemic. So, as we lose biodiversity, we lose alternative hosts for insect vectors to bite and the epidemic becomes concentrated in humans and domestic livestock.

What are the consequences for human health of allowing a natural predator to die out, like the bobcat in North America which preys on white-footed mice infected with ticks, a vector of Lyme disease which can infect humans?

I suspect that the recent outbreaks of prion diseases (chronic wasting disease in deer in the USA and perhaps Scrapie in the UK) are connected to the loss of predators whose main ecosystem service is to eat recently dead carcasses rather than leave them to rot in the landscape.

In regions with very poor soils, antelope and deer tend to be very calcium-deficient. They compensate by chewing on old carcasses at the end of winter when they're really hungry and nutritionally stressed. This is a great way to transmit a prion. However, if you have a healthy and abundant predator and scavenger community, these carcasses are removed by the wolves, coyotes and bobcats before they can transmit their pathogens.

Predators like wolves also disproportionately remove sick animals from herds of elk and deer; this again reduces rates of pathogen transmission within the herd and on to the hunters who may consume meat from animals they have successfully hunted.

Could climate change help animal diseases cross the species barrier to humans?

Climate change is likely to change the diversity of pathogens to which humans are exposed. We simply don't know enough to say whether it changes susceptibility. Nor do we have enough people, or funds, to work on this. In the USA, more bright medical graduates tend to go into sports medicine than into climate-related health problems. So it will be a while until we find out.

This of course increases our worries about the unknown effects of climate change on disease. Lots of things are unknown because we spend a disproportionate amount of money on either self-inflicted human dietary ailments or 'faith-based' vaccine development. There is an enormous reluctance among the medical community to recognize that, if our real goal was reducing the human burden of infectious disease, then money spent on vaccine development would be better spent on relatively simple methods of disease prevention: bed-nets for malaria would be the classic example here but there are many others, particularly among the diseases that are prevalent in the tropics but likely to spread into the temperate zone as climate change progresses.

You are working on the ecology of cholera[5] and climate. What are your initial findings?

Work with Mercedes Pascual and her colleagues at the University of Michigan in Ann Arbor, Michigan (USA), and with colleagues at the International Center for Diarrhoel Disease in Bangladesh has shown that the dynamics of cholera is very dependent upon climate, particularly rainfall and hence river depth and flow. Some of this work is published in the journals *Nature*[6], *Science* and *EcoHealth*; more work is appearing over the next year.

The key thing to note here is that the recently published complete genomes for *Vibrio cholerae* and for humans tell us essentially nothing about this interaction! Instead, our understanding of infection dynamics and seasonal outbreaks has to come from the ecological and mathematical analysis of long-term cholera cases and climate data.

There is a perception in the medical community that genomics will supply all the answers. As we look more and more at the long-term dynamics of cholera and malaria, I think this is unlikely to be the case. Genomics tells us almost nothing about interactions between host and pathogen at the population level and nothing about the influence of climate. This is an epiphenomenon of the same mentality that focuses on vaccine development, when developing a deeper understanding of disease dynamics, and how to break cycles of infection, would be a more effective way to reduce the impact of the pathogen on people who bear the burden of infection.

Too much of the research in medical schools is for the benefit of the egos and career of the researcher and makes negligible contributions to developing effective ways to control infectious diseases. Even the Bill and Melinda Gates Foundation has been woefully misled in funding research for vaccines for which we shall never reach levels of coverage sufficient to have an impact on transmission.

In Central America, the impact of climate change on biodiversity is already visible. This Panamanian golden frog is one of more than 100 species of Harlequin frogs disappearing from the cloud forests and rainforests of Central America. Over the past 20 years, 110 endemic frog species (about 67%) have become extinct, including the Monteverde Harlequin frog and the golden toad. Recent research has shown the critical role of the chytrid fungus coupled with climate change in the extinction of Harlequin frogs: higher air temperatures create optimum conditions for the fungus, while greater daytime cloudiness prevents the frogs from finding thermal refuges from the pathogen. Source: Case Studies on Climate Change and World Heritage *(see also pages 20 and 24)*

Will climate change be the main cause of species loss in coming decades?

Although climate change is a huge worry at the moment, particularly for people living in the Arctic and temperate zones, I actually lose more sleep worrying about habitat loss and rainforest destruction, particularly in the tropics. This not only makes a major contribution to the rate of climate change but it also reduces a major buffer to future rates of environmental change.

Only this month [June], Walter Jetz, David Wilcove and I published an article in *PLOS Biology* on the Projected impacts of Climate and Land-use Change on the Global Diversity of Birds. We used the Millennium Ecosystem Assessment Scenarios to evaluate the exposure of all 8750 land bird species to the projected transformation of land cover due to changes in climate and land use. Even under environmentally benign scenarios, we found that around 400 species will suffer >50% range reductions by 2050, a figure that rises to 900 species by 2100. Species most at risk are predominantly narrow-ranged and endemic to the tropics. The vast majority of these species (>90%) are impacted by land-use change; only the minority suffer significant loss from climate change. In either case, most are currently not recognized as imperiled.

This tells us that, although climate change will have a significant impact this century, habitat loss, particularly in the tropics, will be an even bigger threat to land bird species. This ties in with the Red List[7], which cites habitat loss as the dominant cause of species loss in around 70% of the species listed as threatened or endangered, ahead of habitat fragmentation, overexploitation of populations for food and other economic uses, the introduction of invasive species and diseases, climate change and pollution.

Interview by Susan Schneegans

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5. *Cholera is transmitted from person to person via fecal or oral matter but also via indirect transmission through the environment, such as contaminated food and water. This is why outbreaks are closely tied to poverty and poor public hygiene. The main reservoir for cholera are freshwater invertebrates. This means that, even if we had an effective cholera vaccine, we'd have to vaccinate everyone living close to potential sources and we'd have to repeat this every two to three years. We have never achieved this level of coverage for any of the handful of diseases for which we have lifelong vaccines*

6. *In an article published in* Nature *in August 2005, the team explained how it had analysed 40 years of medical records for cholera in the town of Matlab near Dhaka (Bangladesh). The scientists developed a computer model which took into account two key factors influencing cholera transmission in the area: immunity to the cholera bacterium in local people, thought to last up to three years after an outbreak, and climatic factors like trends in rainfall. Their findings indicated that floods caused by heavy monsoons could contaminate drinking water with the cholera bacterium and that drought also favoured the bacterium, as it developed more easily in small pockets of stagnating water. The authors explained that the team would be turning its attention to designing new computer models based on its findings to provide short-term forecasts of future epidemics and elaborate scenarios for how cholera would be affected by climate change: www.scidev.net/pdffiles/nature/nature03820.pdf*

7. *www.redlist.org*