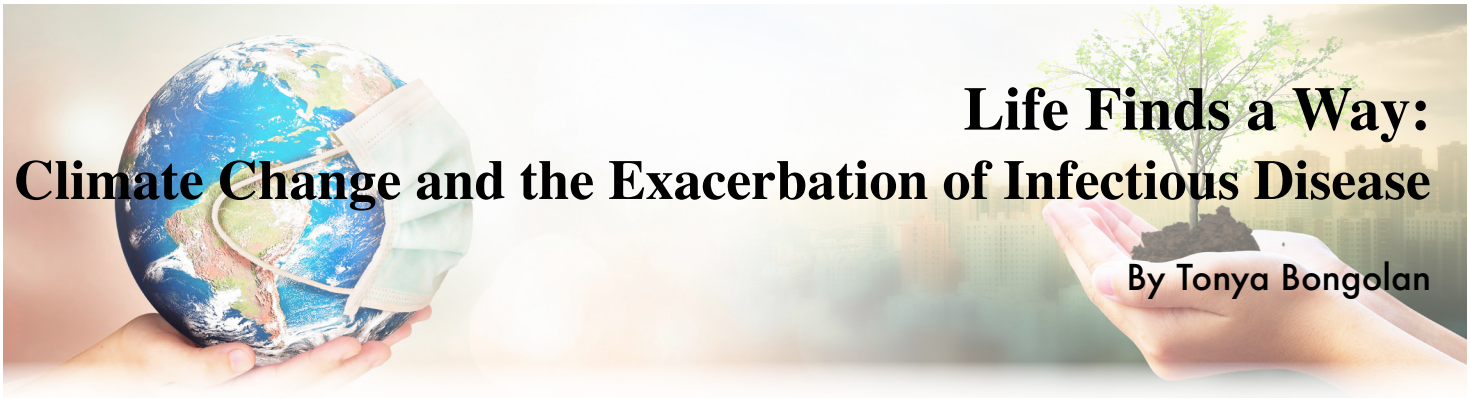


Life Finds a Way: Climate Change and the Exacerbation of Infectious Disease

By Tonya Bongolan

I remember watching Jurassic Park as a kid in the 90s. I thought the premise was so cool – taking dinosaur DNA from a mosquito perfectly preserved in amber and combining it with amphibian DNA to create a new generation of modern-day dinosaurs. How did these humble (and scientifically inaccurate) beginnings quickly spiral into the disaster that resulted in a 2010s trilogy reboot starring Chris Pratt? As Jeff Goldblum's character, Dr. Ian Malcolm, excellently puts it, "life finds a way." That sentiment rings true today, with the lowly mosquito and small animals, yet again, being placed in the middle of the war between Mother Nature and our own hubris.

Humans have played huge roles in driving climate change. The direct effects of climate change on human health are well documented. In the summer of 2021, a doctor in British Columbia noted "climate change" as a medical diagnosis for the first time ever1. As temperatures rose, patients with pre-existing health conditions were found to have exacerbated symptoms due to excessive heat exposure. And yet, there is a more insidious way climate change can affect human health. What is it that we have in common with all kingdoms of life? The ability to move around. Slowly inching toward humans are not only animals and insect populations that we are not well equipped to cohabitate with or be exposed to, but also the threat of infectious disease transmission between species.

While improved sanitation has greatly decreased the spread of infectious disease, the re-emergence of devastating diseases such as Ebola, swine flu, Zika, Middle East Respiratory Syndrome (MERS), and Severe Acute Respiratory Syndrome (SARS) just a few years ago has proven that we must remain vigilant in preventing the further spread of these diseases by looking to other modes of prevention. Infectious disease transmission relies on many different variables. But, it is now becoming increasingly evident that climate change drives much of the changes that occur to produce a "spillover event," whereby a pathogen can jump from species to species. Now, more than ever, we must ensure that the effects of climate change do not lead to an exacerbation of infectious disease in human populations. How exactly does climate change affect the spread of infectious disease, and can we look to climate change as a clear factor in the now two year-long COVID-19 pandemic?

We're Getting Warmer

There are many factors regarding climate change that can drive the exacerbation of infectious disease. This includes variability in air temperature, precipitation, and extreme weather events such as wildfires and flooding that have become rampant in recent years due to unprecedented climate change on a global scale. One of the main effects of climate change has been an increase in air temperatures around the globe, with an average increase of approximately 1°C per year between 1880-20202. This leads to south-to-north spread of infectious diseases that are endemic in areas with warmer temperatures.

An example of this is the population dynamics of Aedes aegypti, the mosquito known to carry dengue, Chikungunya, Zika, and yellow fever. Thus this mosquito is a major source of vector-borne diseases that affect human populations. Ae. aegypti is native to tropical and subtropical regions, but can also thrive in urban areas3. An article published in May 2020 in Nature Communications demonstrates how scientists can predict the population dynamics of Aedes aegypti. Here, Iwamura et al. used a new type of modeling that incorporates changes in environmental conditions that are necessary for Ae. aegypti to thrive, including precipitation and expected increases in temperature due to greenhouse gas emissions4. Their model suggests that

the continued rates of climate change will increase the environmental suitability for Ae. aegypti, leading to an expansion of regions in which Ae. aegypti can thrive and potentially spread vector borne disease to humans. The threat of invasion into North America is predicted to increase from 2 to 6 km per year by 2050. Furthermore, the life cycle-completion of Ae. aegypti, which leads to increased reproduction and overall population, is predicted to increase by 17-24% by 2050, leading to an even higher risk of outbreaks that will affect North American human populations4.

The Nature Communications article is not the only study predicting these trends in mosquito populations. Ryan et al., modeling similar trends in other Aedes populations, have also found that there will be an increase in human exposure to mosquito-borne diseases due to climate change and projected migration patterns, with the prediction that nearly one billion people will be exposed to new viruses carried by Aedes mosquitoes within the next century5. By using research models that consider the changes in environment caused by climate change, researchers can predict the migration of whole populations of insects, bringing to light the interconnectedness of infectious disease and global warming. Changes in climate do not affect only insect migration patterns, but also animal migration patterns, which now sits at the forefront as a major cause of the COVID-19 pandemic.

From Bat to Man: Zoonotic Spillover Leading to the COVID-19 Pandemic

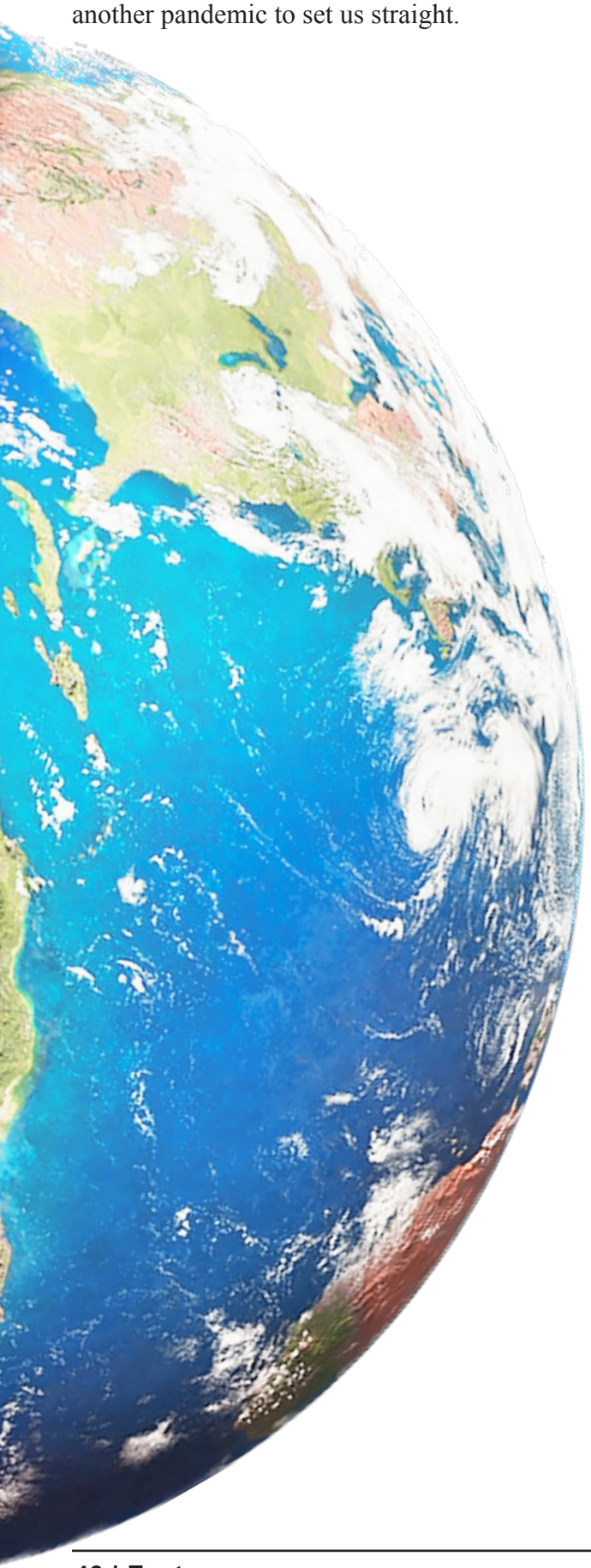
At the beginning of the pandemic, there were many questions regarding the origins of SARS-CoV-2, the virus that causes the 2019 coronavirus disease. Following an investigation led by the World Health Organization, it is now widely accepted that SARS-CoV-2 most likely originated in bats and transferred to humans through another animal carrier6-8. Thus, research towards the understanding of bat populations around the globe can shed light on the origins of SARS-CoV-2, and if there are specific environmental factors that led to this zoonotic spillover event that ravaged the entire globe.

It is estimated that there are over 3000 different coronaviruses carried by the world's bat population9, with evidence suggesting that the viruses responsible for the MERS and SARS outbreaks are of bat origins10,11. Because bats carry so many of the world's viruses and are capable of mass migration, scientists now believe that a greater diversity in bat species saturated in one geographical region poses higher threat of zoonotic spillover events, especially in areas heavily populated with humans. Bat migration, like the patterns seen in Ae. aegypti, is currently experiencing a range-shift, with environmental suitability increasing as a result of climate change. Beyer et al. found that regions in Central Africa, South America, and Southern China are among the parts of the world that have increased bat species richness between 1930-2019 as a result of climate change, with ~40 new bat species found around the Yunnan province of China, the likely origin of SARS-CoV-2 zoonotic spillover to humans12. They also measured a change in vegetation caused by increased temperatures, from shrubland to woodland forests, which is the ideal habitat for bat populations to thrive12. While there are many other factors that drove the spread of the current pandemic, such as lack of appropriate public health measures and global travel, we cannot ignore the science that posits the role of climate change as a driving factor in the ongoing battle against infectious disease transmission.

Lessons Learned

If the past two years have taught us anything, it is that, "life finds a way." It is no exaggeration that the human population is giving life too many ways to find. In allowing climate change to continue, we are adding fuel to the fire, causing humans to suffer through devastating outbreaks that are highly preventable simply by having barriers between populations of humans, insects, and animals. In order to slow the rate of spillover events and infectious disease outbreaks, we must continue to research how insect and animal migration patterns have drastically changed over the course of the century as a result of climate change. In doing so, we can model how this will affect the trajectory of infectious disease in human populations. By evaluating the threat of infectious disease spillover events, we can pre-emptively act to limit this spread. This must come with direct action to preserve the natural habitats of these animals, as well as strengthening food and safety regulations where hunting and selling animals is involved. Ultimately, the reduction of greenhouse gas emissions will slow the global increases in air temperatures and halt the further spread of insect and animal populations to non-native regions. We often talk about a "point of no return" with climate change, whereby even if greenhouse gas emissions were at zero, there is no stopping global warming from

continuing. It is time we consider infectious disease as a crucial factor in the fight against global warming. We cannot wait for a Jurassic Park-esque catastrophe or another pandemic to set us straight.



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