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How the speed of climate change is unbalancing the insect world

The climate crisis is set to profoundly alter the world around us. Humans will not be the only species to suffer from the calamity. Huge waves of die-offs will be triggered across the animal kingdom as coral reefs turn ghostly white and tropical rainforests collapse.

For a period, some researchers suspected that insects may be less affected, or at least more adaptable, than mammals, birds and other groups of creatures. With their large, elastic populations and their defiance of previous mass extinction events, surely insects will do better than most in the teeth of the climate emergency?

Sadly not. At 3.2C of warming, which many scientists still fear the world will get close to by the end of this century (although a flurry of promises at Cop26 have brought the expected temperature increase down to 2.4C), half of all insect species will lose more than half of their current habitable range. This is about double the proportion of vertebrates and higher even than for plants, which lack wings or legs to quickly relocate themselves. This huge contraction in livable space is being heaped on to the existing woes faced by insects from habitat loss and pesticide use. “The insects that are still hanging in there are going to get hit by climate change as well,” says Rachel Warren, a biologist at the University of East Anglia, who in 2018 published research into what combinations of temperature, rainfall and other climatic conditions each species can tolerate.

Butterflies and moths are also often quite mobile, but in different stages of their life cycle they rely on certain terrestrial conditions and particular plant foods, and so many are still vulnerable. Pollinators such as bees and flies can generally move only short distances, exacerbating an emerging food security crisis where farmers will struggle to grow certain foods not just due to a lack of pollination but because, beyond an increase of 3C or so, vast swaths of land simply becomes unsuitable for many crops. The area available to grow abundant coffee and chocolate, for example, is expected to shrivel as tropical regions surge to temperatures unseen in human history.

The climate crisis interlocks with so many other maladies – poverty, racism, social unrest, inequality, the crushing of wildlife – that it can be easy to overlook how it has viciously ensnared insects. The problem also feels more intractable. “Climate change is tricky because it’s hard to combat,” says Matt Forister, a professor of biology at the University of Nevada. “Pesticides are relatively straightforward by comparison but climate change can alter the water table, affect the predators, affect the plants. It’s multifaceted.”

Insects are under fire from the poles to the tropics. The Arctic bumblebee, Bombus polaris, is found in the northern extremities of Alaska, Canada, Scandinavia and Russia. It is able to survive near-freezing temperatures due to dense hair that traps heat and its ability to use conical flowers, like the Arctic poppy, to magnify the sun’s rays to warm itself up. Rocketing temperatures in the Arctic, however, mean the bee is likely to become extinct by 2050. Species of alpine butterflies, dependent on just one or two high-altitude plants, are also facing severe declines as their environment transforms around them.

Further south, in the UK, glowworm numbers have collapsed by three-quarters since 2001, research has found, with the climate crisis considered the primary culprit. The larvae of the insects feed on snails that thrive in damp conditions, but a string of hot and dry summers has left the glowworms critically short of prey.

These sort of losses in Europe have challenged previous assumptions that insects in temperate climates would be able to cope with a few degrees of extra heat, unlike the mass of species crowded at the world’s tropics that are already at the upper limits of their temperature tolerance. A team of researchers from Sweden and Spain have pointed out that the vast majority of insects in temperate zones are inactive during cold periods. When just the warmer, active, months of

insects' lives were considered by the scientists, they found that species in temperate areas are also starting to bump into the ceiling of livable temperature. As Frank Johansson, an academic at Sweden's Uppsala University, glumly puts it: "Insects in temperate zones might be as threatened by climate change as those in the tropics."

Bumblebees, those large, furry insects permanently sewn into their winter coats, are at the pointy end of this rising heat. A study by the University of Ottawa in 2020 found that bumblebee populations in North America have nearly halved, with those across Europe declining by 17%.

Some scientists have warned that the correlation shown in this research has yet to prove causation, but there is a broad acceptance that changes in temperature and rainfall could overwhelm insects already facing a barrage of threats. In 2019, for example, scientists revealed the happy news that nine new bee species had been discovered in the south Pacific island of Fiji, only to then immediately note that many of them face climate-related extinction due to their warming mountaintop habitats. "In the future, climate change is going to be the nail in the coffin for quite a lot of creatures which are already in much reduced numbers," says Dave Goulson, a University of Sussex ecologist. "They'll simply be unable to cope with a 2C rise in temperature and all the extreme weather events that are likely to go with that."

Even the Amazon rainforest, that humming trove of insect life, is seeing complex relationships torn asunder. The increasing incidence of the El Niño phenomenon, coupled with human interventions such as deforestation, are spurring more intense drought and wildfires. Researchers were shocked to find this changing regime causing a population collapse among the humble dung beetles, which are key distributors of nutrients and seeds and important indicator species of the health of an ecosystem. Counts of beetles before and after an El Niño event in 2016 found that insect numbers had been cut by more than half within the studied forests. The climate crisis is making the Amazon drier, more brittle and more prone to fires, while also stripping away the unheralded dung beetles that help regenerate burned forests. "I thought the beetles would be more resilient to drought than they were," says Filipe França, the Brazilian scientist who led the research. "If climate change continues we'll not only see less biodiverse forests but also make them less able to recover after further disturbances."

Insects are so interlaced with the environment that they acutely feel any jolt to the regular rhythms of life. Spring is being pushed earlier and earlier in the year, unsettling the established life cycle of insects. In the UK, moths and butterflies are emerging from their cocoons up to six days earlier a decade on average, while in parts of the US, springtime conditions that trigger insect activity occur as much as 20 days earlier than they did 70 years ago. Most plant and animal species rely on the buildup of heat in spring to set in motion flowering, breeding and hatching of insect eggs. The reshuffling of the season's start risks throwing delicately poised interactions off-kilter, such as birds setting off on migration early only to find a food source isn't quite ready for them yet.

British scientists who looked at half a century of UK data found that aphids are now emerging a month earlier than they once did, due to rising temperatures, while birds are laying eggs a week earlier. The aphids aren't necessarily growing in number, despite their elongated season, but their earlier appearances means they are targeting plants that are younger and more vulnerable.

"There's good evidence here in the UK that under climate change things are warming up early, so we've got all these bees coming out early but not the flowers, because obviously the day length isn't changing," says Simon Potts, a bee expert at the University of Reading. "We're getting this decoupling between pollinators and the plants and that's starting to mess up all these very delicate, very sophisticated food webs."

For some insects, a warmer Britain is a welcome development. In recent years, insects such as the violet carpenter bee and the camel cricket have crossed the Channel and established themselves, while some native butterflies, such as the marbled white, are hauling themselves out of population declines with a climate-assisted march northward to cooler climes. Flowers such as wild orchids are heading north, too.

These adaptive techniques will mean little when climate breakdown warps the properties of the plants themselves, diminishing them as a food source wherever insects can find them. Scientists have found that CO2 can reduce the

nutritional value of plants, providing insects with a meal of empty calories lacking elements such as zinc and sodium. A study site in the prairies of Kansas found that grasshopper numbers there are dropping by around 2% a year, and researchers felt confident enough to rule out pesticide use or habitat loss as the likely cause. Instead, they concluded that the grasshoppers were suffering starvation via the climate emergency.

Not only is climate breakdown potentially causing insects to be malnourished; it also appears to be altering the scent of plants. Pollinators searching for food will note the colour and number of flowers as well as the plant's scent, with bees able to recall a fragrance and associate it with certain plants and their nectar content. Scientists who measured the fragrance molecules emitted by rosemary in shrubland near Marseille, in France, discovered that a different scent was given off by plants that were stressed, which deterred domesticated bees. As the climate crisis stresses more plants by subjecting them to drought and soaring heat, insects may find them not only a bland meal but also unappealing to even approach.

This alteration in plants may be, for insects at least, the most far-reaching symptom of climate breakdown.

ot all insects are doomed in a warming world, however. As with all realignments, there are winners and losers, and our attention is more easily captured by thoughts of hordes of marauding insects unshackled by global heating than by a handful of scientists fretting about a declining desert moth. In 2020, east Africa suffered its worst plague of locusts in decades. The previous year, the Horn of Africa had been pounded by rainfall, up to 400% above average levels, aiding the reproduction of locusts. Increased heat is also thought to boost locust numbers, with both factors heavily influenced by climate breakdown. Farmers in Kenya watched on helplessly as the sky darkened with locusts that descended to decimate their corn and sorghum. Separate, massive swarms then broke out in western and central India, chewing up land at a rate not seen in a generation.

A hotter world is likely to bring an array of insect pests and pathogens to attack potatoes, soya beans, wheat, and other crops. A group of American researchers calculated that yields of the three most important grain crops – wheat, rice, and corn – lost to insects will increase by as much as 25% per degree Celsius of warming, with countries in temperate areas hit the hardest. Crop pests also tend to thrive in simplified environments that have been stripped of their predators – another legacy of monocultural farming practices.

n the American suburbs, we will see more emerald ash borers, the brilliantly green beetles native to Asia that were introduced to the US after a few of them clung to some wooden packaging that made its way to Detroit. The rapacious beetles have killed off hundreds of million of ash trees across North America and are now establishing themselves in eastern Europe. Milder winters mean the pests will be able to spread farther north, causing further devastation.

Even the domestic environment will see a new influx of unwanted insects, with populations of houseflies more than doubling by 2080, according to one estimate, due to changes in temperature, humidity and rainfall. But while houseflies can cause illness through the transfer of waste on to food, at least they aren't major vectors of deadly conditions.

It is worrisome, therefore, that there's an expansion under way of mosquitoes.

Freezing temperatures tend to kill mosquito eggs. This means that a heated-up planet is allowing the insects to conquer new territories, helping trigger outbreaks of dengue in France and Croatia, chikungunya in Italy and malaria in Greece in the past decade. These incursions are likely to be vanguards; the Mediterranean region is already a partly tropical region, and as heat and moisture continue to build, the central swath of Europe and even the southern regions of the UK will be within striking range of a fearsome cadre of newcomers. "If it gets warmer we could get West Nile. Malaria could come back, too," says Simon Leather, a British entomologist. "We could see a real change in terms of human health problems."

Mosquitoes are clearly, by the number of people killed, the most deadly animal on Earth to humans; but in our eagerness to vanquish them, we often deploy weapons with high levels of collateral damage. The chemical compound DDT was developed for widespread anti-mosquito use – before mosquitoes developed resistance and the chemical's pernicious impact on other wildlife led to its ban. A more recent replacement, an organophosphate called naled, is now

sprayed on mosquito habitat despite evidence that it is toxic to bees, fish and other creatures. But if our fears of a seething invasion of heat-loving insects were to be embodied by one animal, it would probably be the Asian giant hornet.

You might have heard it referred to as a “murder” hornet. The bulky, thumb-sized hornet has the demeanour of a cartoonish supervillain, with its tiger-striped abdomen, large burnt orange-coloured face, teardrop eyes like a demonic Spider-Man and a pair of vicious mandibles. Despite a flurry of public concern to the contrary, murder hornets do not murder people; they kill honeybees. The hornets loiter outside bee hives and gruesomely decapitate emerging worker bees, dismembering the unfortunate victims and feeding the body parts to their larvae.

This carnage can go on until a hive is completely annihilated, the crime scene marked by thousands of scattered corpses. In some places, bees do fight back. Bees in the hornets’ native range have evolved a defensive tactic whereby a mob of bees will hurl themselves at a hornet that enters the hive, covering the invader in a ball-like mass and then vibrating their flight muscles to generate so much heat, up to 47C, that the hornet is roasted alive. Honeybees in Europe and North America, however, are unused to the hornet and are essentially helpless in face of the slaughter.

As its name suggests, the Asian giant hornet (Vespa mandarinia) is native to the forests and mountain foothills of east and south-east Asia. It is commonly mixed up with its cousin, the Asian hornet (Vespa velutina), which has found its way to Europe and dismembered so many honeybees in the UK and France that bee-keepers have fretted over the viability of colonies already under stress from varroa mites and pesticides. Vespa mandarinia, meanwhile, has launched an assault on the western coast of North America, most likely hitching a ride over on cargo shipping.

Three confirmed specimens were discovered by surprised Canadian authorities on Vancouver Island in August 2019, then another hornet was found further south, close to the US border. By December, the species was spotted again, this time in the US, about 12 miles further south in the state of Washington. One beekeeper, stung a few times by irate hornets, set the entire colony on fire to destroy it. Another fresh hornet queen, found 15 miles south-west of the next nearest find, suggested either a repeated influx from overseas or a vigorous dispersal by the hornets.

By May 2020, with the hornet appearing to have gained a decent foothold on the west coast, the situation had attracted the attention of the New York Times, which ran a story headlined “‘Murder Hornets’ in the US: The Rush to Stop the Asian Giant Hornet.” Climate change could help turbocharge the pace of the hornet’s advance, similar to the astonishing travels of the Asian hornet in France, where it has moved at nearly 50 miles a year since arriving in the early 00s and is now found in the Alps.

It’s natural to get squeamish over the idea of a squadron of murderous hornets or the idea that those ever-durable cockroaches will march on despite the surging heat. The genuinely scary part of all this, though, is climate breakdown itself, an existential threat we have brought upon ourselves and all other living creatures that we still, despite decades of increasingly frantic warnings, move too sluggishly to avert.

But as we’ve reacted so grudgingly and ponderously to the menace of flooding, storms and droughts that can spark civil unrest and even wars, what hope is there that the plight of insects will spur us on? A more realistic goal is a concerted effort to restore complex, connected insect-friendly habitat and ensure that it remains largely toxin free, in the hope that this will at least parcel out a little time and space from the onslaught of the climate crisis. Although climate breakdown can often feel like a drawn-out, almost imperceptible rearrangement that far-off generations will have to deal with, it is also punctuated with lacerating reminders that it’s already well under way.

This is an edited extract from **The Insect Crisis: the fall of the tiny empires that run the world**, Oliver Milman, March 2022