Urban lighting and the caterpillar

street lamps darken the prospects of insect populations

Elephant Hawk-moths

Surveying moth caterpillars for the study

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High-lux illumination of urban centres after sundown has been linked with several reasons to tone it down. The purpose of lights at night, of course, is more hours of economic activity, but the cost is power consumption and health issues caused by disrupting the day-night cycle.

The other cost is to the environment. While humans have adapted in some ways, animal populations, generally, have not. A paper in the journal, *Science Advances*, goes into the effect that night-time illumination has on insect populations. Douglas H Boyes, Darren M Evans, Richard Fox, Mark S Parsons and Michael J O Pocock, from UK Centre for Ecology and Hydrology, at Wallingford, the Newcastle University, and Butterfly Conservation, a United Kingdom-wide body for butterflies and moths, describe how street lighting causes a form of environmental damage that could have far-reaching consequences.

The main components that keep the environment in order are the atmosphere, vegetation, ocean currents and climate. Underlying these wider components, however, are the roles of micro-organisms and the insects that ecosystems contain. Microbes, which account for more than half the mass of all living things, are the agents that make the nitrogen of the atmosphere available for the entire plant, and hence animal kingdoms. While microbes thus provide the bases, it is the insect population, of nearly a million different species, that enables the ecosystem to function — insects are vehicles of pollination, and they form the food for myriad other species that play their own roles in maintaining the ecosystem. Insects could be considered the currency of the ecological economy.

The paper starts with the mention of growing evidence that some land-based insect populations have declined over the last few decades. It causes concern about the future of ecosystems, the paper says. And one of the best studied groups, the paper says, are moths, which "are functionally important for terrestrial ecosystems, including as pollinators, prey for both vertebrates (like birds and bats) and invertebrates (like spiders and social wasps), and hosts for parasitoids (other insects that attack pests)." And hence, the paper adds, "these changes are expected to have substantial cascading consequences for ecosystems."

Indeed, the consequences could be serious. The systems of the Earth are maintained by the balance between two main processes. On the one hand, of the pace of metabolism, or changing food to energy, in living things, or human-made processes, like combustion. And, on the other hand, the Earth's green cover, using the Sun's energy to undo results of the first process. With the first process having gone out of hand, the Earth is now facing a crisis. And a large part of the solution, it appears, lies in making use of microbes and natural processes, both to repair and provide energy for lifestyles. In this context, damage to the ecology of microbes and insects would precipitate a crisis from which there may be no recovery.

Having started with saying that insect populations are decreasing, the paper says it is being "increasingly recognised that artificial illumination that we use at night is a serious threat to biodiversity and ecosystem processes". The diverse insect species that act in concert to maintain our ecosystem have evolved over geological eons. And through the long period of evolution, there has been negligible night-time illumination, beyond moonlight or starlight. The emergence of brightly lit cities and lighting of streets, even highways in rural areas, the paper says, has had wide-ranging negative effects on insect life, inhibiting both caterpillar feeding and adult activity, restricting reproduction and facilitating predation.

Despite strong grounds to believe that night-time illumination affects insect behaviour, however, there is limited empirical evidence to say that artificial lighting at night is a driver of the decline of insect populations, the paper says. The authors hence undertook a study, using a "matched pairs" experiment design — of comparing the effect that existing direct lighting had on the habitats of wild caterpillars, with carefully matched habitats which were unlit. This approach, of studies over large, naturally occurring insect populations, promised to be more reliable, apart from being cheaper and more versatile, than creating insect colonies for "manipulative" studies, the paper says.

Moths were the specific insects studied, and which were taken to represent insects, generally. And the focus was on the less mobile, caterpillar stage of the moth life-cycle. That was because studying the effect of illumination on the caterpillars would directly relate to the effect on adult moth populations, the paper explains.

The caterpillar populations were sampled in two kinds of habitat, hedgerows and grass margins. And in pairs, of areas that were illuminated with streetlights, and matching areas with identical or similar shrubbery, that were not illuminated. The sampling of hedgerows was done in mid-May 2019 (end of the moth-caterpillar feeding season) and mid-April 2020 (start of the feeding season). The sampling of grass margins was for another species of moth-caterpillars, during mild nights from November to April.

The results of the trials were that there was distinctly lower caterpillar abundance in the areas lit by halogen lamps — 41 per cent less in the hedgerows and 24 per cent less in the grass margins. The paper notes that there is a trend of halogen lamps, used for night-time illumination, being replaced by light-emitting diode lamps, as LEDs are energy efficient and considered to be "eco-friendly". The study hence covered areas illuminated by LED lamps too.

The findings were that the areas lit by LEDs showed a 52 per cent drop in caterpillar abundance, while the areas lit by halogen lamps showed a drop of 43 per cent. Although LED lamps appear to attract less moths than halogen lamps, what is seen is that LED lighting is more disruptive for the moth population. It is a source of concern, the paper says, as the use of white light, LED lamps is rising. It is possible, however, to control the intensity and spectrum of LED lamps, the paper says, and this may help regulate their effects.

The study hence provides strong evidence that street lighting has the effect of reducing wild insect populations. One reason could be that fewer eggs are laid in illuminated areas, as the activity of moths is disrupted. And there are indirect effects, like opening opportunities for predators, or for other insects that "help" plants by eliminating caterpillars. There is also the effect of lighting enabling plants to more effectively resist being fed upon by caterpillars.

The study is an important step in understanding the importance of light pollution as a factor affecting insect abundance, compared to drivers like habitat loss and climate change. And also, to stress the importance of insects, as essential actors in pollination, as well as forming the start of the animal food chain.

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PLUS POINTS

Reptile ancestor

Scientists have unearthed the 231 million-year-old fossil of a species that is an ancient forerunner of most modern reptiles.

According to the researchers, including those from Harvard University in the United States, the fossil, unearthed in Argentina, represents an ancient species that was an ancestor to Lepidosauria — a group that includes all lizards and snakes — and is the largest group of terrestrial vertebrates with approximately 11,000 species.

While the lineages of Lepidosauria are older than dinosaurs, originating and diverging from each other around 260 million years ago, the scientists say the early phase of this group's evolution, about 260-150 million years ago, has remained a mystery, marked by very fragmented fossils — until now.

In the current research, published recently in the journal *Nature*, the scientists describe a new species that represents the most primitive member of lepidosaurs, *Taytalura alcoberi*, based on the first three-dimensionally preserved early lepidosaur fossil.

"I knew the age and locality of the fossil and could tell by examining some of its external features that it was closely related to lizards, but it looked more primitive than a true lizard and that is something quite special," Tiago R Simoes, a co-author of the study from Harvard University, said in a statement.

In the research, the scientists processed data from the fossil specimen's computed tomography X-ray scans and created a mosaic of colours for each bone of the skull. They say this allowed them to understand the fossil's anatomy in high-detail resolution on a scale of only a few micrometres — about the same thickness as a human hair.

On further analysis, they found that *Taytalura* is the most primitive member of the lineage that eventually originated all lizards and snakes. "It's not even a lizard in the evolutionary tree," Simoes said, adding that, "it's the very next thing there," between true lizards, all other reptiles, and the last remaining species of tuatara in New Zealand.

"This beautifully 3D preserved fossil is really an important finding. It is the most complete fossil representing the early stages of lepidosaur evolution that we have so far," Gabriela Sobral, another co-author of the study from the State Museum of Natural History in Stuttgart, Germany, said in a statement, "All other known fossils are too incomplete, which makes it difficult to classify them for sure, but the complete and articulated nature of *Taytalura* makes its relationships much more certain."

While the perfectly preserved *Taytalura* skull reveals how a very successful group of animals, including more than 10,000 species of snakes, lizards, and tuataras, originated, scientists say it also highlights the importance of the fossil site of Ischigualasto Formation where some of the most primitive dinosaur specimen have been unearthed.

"The extraordinary quality of preservation of the fossils at this site allowed something as fragile and tiny as this specimen to be preserved for 231 million years," Ricardo N Martínez, a co-author of the study from The National University of San Juan, said in a statement.

While almost all fossils of lepidosaurs from this Triassic period — 252-201 million years ago — is found in Europe, the researchers say this is the first fossil of an early lepidosaur found in South America, suggesting the creatures in this group were able to migrate across vastly distant geographic regions even early in their evolutionary history.

The researchers plan to next explore older sites in hopes of finding different species from the same lineage that branch just before the origin of true lizards.

—The independent

PROVEN BENEFITS

Vaccines could affect how the coronavirus evolves — but that's no reason to skip your shot

ANDREW READ

In 2015, my collaborators and I published a scientific paper about a chicken virus you have likely never heard of. At the time, it got some media attention and has been cited by other scientists in the years since.

But now, by late-August 2021, the paper has been viewed more than 350,000 times — and 70 per cent of those views were in the last three weeks. It has even appeared on a *YouTube* video that's been seen by 2.8 million people and counting.

The paper has gone viral because some people are using it to stoke paranoia that the Covid-19 vaccines will cause the virus to evolve in the direction of even more severe variants. Doctors have told me that patients are using the paper to justify their decision to not get vaccinated. Some pundits are even using it to urge an end to vaccination campaigns in order to prevent the sort of viral evolution we were studying in chickens.

I am receiving emails daily from people worried about getting vaccinated themselves or worried about people rejecting vaccination because of misunderstandings about the paper.

Nothing in our paper remotely justifies an anti-vaccine stance. That misinterpretation — if it causes people to choose not to be vaccinated — will lead to avoidable, and tragic, loss of life. A new study estimates that as of early May 2021, vaccines had already prevented nearly 140,000 deaths in the United States.

For over 20 years I've been working with collaborators and colleagues on how vaccines might affect the evolution of disease-causing organisms like viruses and malaria parasites. Nothing we have discovered or even hypothesised justifies avoiding or withholding vaccines. If anything, our work adds to reasons for investigating new vaccine schedules — and for developing second- and third-generation vaccines.

But in the context of the Covid-19 virus, our work does prompt a fair question: could vaccination cause the emergence of even more harmful variants?

From chickens to Covid-19

In the 2015 paper, we reported experiments with variants of Marek's disease virus — the name of the chicken virus we were studying. It is a herpesvirus that causes cancer in domestic chickens. A first-generation vaccine against it went into widespread use in poultry in the early 1970s. Today, all commercial chickens and many backyard flocks are vaccinated against Marek's.

Chickens with Marek's disease virus became capable of transmitting the virus about 10 days after they get infected. In our lab experiments, we worked with variants of Marek's disease virus that were so lethal they would kill all unvaccinated birds in 10 days or fewer. So, prior to the vaccine, the birds died before they could transmit the lethal variants to other birds. But we found that the first-generation vaccine protected the birds from dying. In other words, the Marek's-infected chickens lived and were thus able to spread the highly virulent strains to other birds.

In the case of Covid-19, it's becoming increasingly clear that even vaccinated people can contract and transmit the highly transmissible delta variant. Since viral transmission from vaccinated chickens is what allowed more lethal variants to spread in Marek's, it's reasonable to ask whether Covid-19 transmission from vaccinated people could allow more lethal variants to spread.

Evolution can go in many directions

As evolutionary ecologist David Kennedy and I have written about previously, the evolutionary path that the Marek's disease virus took is one of many that are possible — in rare cases where vaccines drive evolution.

Only a minority of human and animal vaccines have influenced pathogen evolution. In nearly all those cases — which include the hepatitis B virus and bacteria that cause whooping cough and pneumonia — vaccine efficacy was reduced by new variants. But in contrast to Marek's, there was no clear evidence that the evolved variants made people sicker.

In nature, we know of course that not all viruses are equally lethal. Biological differences in things like the linkage between disease severity and transmission can cause lethality to increase or decrease. This means that the future of one virus cannot be predicted by simply extrapolating from the past evolution of another.

Marek's and Sars-CoV-2 are very different viruses, with very different vaccines, very different hosts and very different mechanisms by which they sicken and kill. It is impossible to know whether their differences are more important than their similarities.

Evolutionary hypotheticals are important to consider. But up against the hugely beneficial impact of Covid-19 vaccines on reducing transmission and disease severity — even against the delta variant — the possibility of silent spread of more lethal variants among the vaccinated is still no argument against vaccination.

As novel variants of the coronavirus spread in the months and years ahead, it will be vital to work out whether their evolutionary advantage is arising because of reduced disease severity among the vaccinated. Delta, for instance, transmits more effectively from both unvaccinated and vaccinated people than did earlier variants. Extrapolating from our chicken work to argue against vaccination because of the delta variant has no scientific rationale: The delta variant would have become dominant even if everyone refused vaccination.

But what if?

If more deadly variants of the coronavirus were to arise, lower vaccination rates would make it easier to identify and contain them because unvaccinated people would suffer more severe infections and higher death rates. But that kind of "solution" would come at considerable cost. In effect, the variants would be found and eliminated by letting people get sick, many of whom would die.

Sacrificing chickens was not the solution the poultry industry adopted for Marek's disease virus. Instead, more potent vaccines were developed. Those newer vaccines provided excellent disease control, and no lethal breakthrough variants of Marek's have emerged in over 20 years.

There are probably ways the available Covid-19 vaccines could be improved in the future to better reduce transmission. Booster shots, larger doses or different intervals between doses might help; so too, combinations of existing vaccines. Researchers are working hard on these questions. Next-generation vaccines might be even better at blocking transmission. Nasal vaccines, for instance, might effectively curtail transmission because they more specifically target the location of transmissible virus.

As of late August 2021, more than 625,000 Americans have died from a disease that is now largely vaccine preventable. It is sobering for me to think that some of the next to die might have avoided life-saving vaccines because people are stoking evolutionary fears extrapolated from our research in chickens.

In the history of human and animal vaccines, there have not been many cases of vaccine-driven evolution. But in every one of them, individuals and populations have always been better off when vaccinated. At every point in the 50-year history of vaccination against Marek's disease, an individual chicken exposed to the virus was healthier if it was vaccinated.

Variants may have reduced the benefit of vaccination, but they never eliminated the benefit. Evolution is no reason to avoid vaccination.

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