Cities are driving evolution — and may spawn new species, scientists say

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Our cities are reshaping the animals and plants that live in them, pushing some to evolve and even spawning new species more quickly and more often than you might think, scientists say.

Scientific evidence suggests:

- The beaks of birds like house finches and great tits are getting bigger so they can more easily eat from backyard bird feeders in Tucson, Arizona, and Oxford, England, respectively.
- Lizards called crested anoles are growing longer limbs and stickier toes for climbing buildings in Puerto Rican cities.
- Fish and pests are developing resistance to human pollutants and poisons.
- A mosquito that lives underground appears to be emerging as a new species from sewers and subway tunnels beneath cities around the world. It has different genes, feeding and breeding habits from its cousins, a species known as *Culex pipiens*, that live above ground.

Those are just some of the dozens of examples uncovered by University of Toronto biology professor Marc Johnson and Jason Munshi-South, a biology professor at Fordham University in New York. The pair pored through the scientific literature and looked for patterns among 192 studies that appear to show evolution in action in urban settings. They published their results in the journal Science Thursday.

A great tit flies out of a hole in a wall in Petersdorf, Germany. Great tits in Oxford, England, have been evolving longer beaks. There's evidence that this is linked to their use of bird feeders. (The Associated Press)

Evolution is the change in species over generations caused by changes in how common different genes are in the population. Those genes, in turn, can have huge effects on how organisms look, behave, and respond to their environment.

So the researchers looked for studies that showed those kinds of changes in urban settings, where noise, pollution, artificial lights, asphalt roads, brick and glass buildings, concrete tunnels and other features make them very different from the natural environments species originally evolved in.

The researchers found several main ways that cities are pushing animals, plants and other organisms to evolve:

- Urban pollution boosts the mutation rate in many species. For example, a study in Hamilton found this effect in gulls and mice near the city's steel plants.
- Structures like highways are isolating populations of many species, like the red-backed salamanders of Mont-Royal in Montreal. Such species are becoming genetically different over time from populations in nearby parks.
- Some species, like house finches and crested anoles, are adapting to urban environments via natural selection.

Pests like bedbugs are evolving via natural selection to become resistant to poisons. (The Associated Press)

CBC News chatted with Johnson about the details of the study. Here's a condensed version of the interview:

Why did you decide to do this study?

I actually don't like cities that much, but being a professor with young family, I'm now kind of stuck in one of North America's largest cities. I started realizing there's pretty amazing biology all around us, and we have very little understandingof how the development of cities and urbanization in general, which is happening throughout the world, is influencing not only the ecology but also the evolution of the organisms that live around us and sometimes even with and in some cases on or in us.

How does one tell if evolution is happening?

Well, it's actually relatively easy, in that evolution is defined in its simplest form as a change in the frequency of alleles or genes within a population through time. And so if you can track a population and if you can detect changes in the frequency of the genes within those populations, then you have direct observable evidence for evolutionary change. Then you can link how those genetic changes are leading to changes in say traits of that organism. For example, that may be traits such as the ability for plant to defend itself against parasites. Or it could be ability for a pest like cockroaches, bedbugs or rats to resist the poisons that we're often throwing at them.

Structures like highways are isolating populations of many species, like the red-backed salamanders of Mont-Royal in Montreal. Such species are becoming genetically different over time from populations in nearby parks. (Judy Gallagher/Flickr, licenced under cc-by-2.0)

How long does it take? Are cities old enough to see those changes?

Some of the oldest cities that we looked at are up to 900 years old — in North America, typically 200 years, 250 years kind of being on the older end. For a long time, including when Darwin originally proposed his theory of evolution by natural selection, we thought evolution was a very slow and gradual process.

In the last 20 years especially, we've become increasingly aware that evolution can actually happen a lot faster that we originally think. You can detect and literally watch evolution happen in as little as two generations. So in as little as 10 generations, you can see relatively rapid and marked evolution, genetically and in the traits. And that amount of time is certainly within the realm of time that cities have been around.

It sounds like the evolutionary changes could be good or bad.

Say we have a native species that is rare and of conservation concern. If it can't adapt to the change in that urban environment, it will go extinct. If it can adapt to the change in that environment, that may allow it to persist and then to have consequences for other members of the community and maybe the entire ecosystem.

From a human perspective, the ability for a pest species, like cockroaches, rats, bedbugs, mosquitoes to adapt to pesticides that we're throwing at them or adapt to any environmental change associated with a city could be a bad thing if it's increasing the rate at which they're transmitting diseases to humans.

Evidence suggests lizards called crested anoles are growing longer limbs and stickier toes for climbing buildings in cities in Puerto Rico. (postdlf, licenced under CC BY-SA 3.0)

Are new species being formed in cities?

There's a very interesting example of where we think a new species is being formed as a result of urbanization. This is a mosquito in this case, *Culix pipiens*, is the scientific name, and this mosquito was initially encountered most dramatically during the Second World War, where individuals during bombing raids had to go into the underground for protection and they were ravaged by mosquito.

It turns out this is a mosquito that was related to mosquitoes that live above ground, but had become strongly genetically differentiated and changed in a lot of behaviours and life history. For example, these mosquitoes that live underground don't need a blood meal in order to make eggs. They also don't go into kind of a dormant period during

the winter. And they don't even recognize individuals above ground as their own species. They will not mate with them. And that is the litmus test of whether new species have formed.

Has a new species formed? Well, maybe. Or maybe it's in the process of forming. It turns out that this same process of the same mosquito, this underground mosquito, occurs in Chicago, New York City and other North American cities.

Maybe cities could lead to the evolution of new species, and there's some indication that may be happening.

You found evidence that humans are also evolving. Can you tell me about that?

There is a very interesting study that's looking at how evolution in our genomes is related to the age of the cities. They find that in one particular area of our genome, this gene that's involved in resistance to endocellular parasites like leprosy, we have higher incidence of resistant mutations in individuals that are living in the oldest cities.

The implication is that perhaps there's been a longer history of people living in cities with those diseases and they've evolved increased resistance. So this is a very interesting study, it's very suggestive, but it is not yet conclusive.

Why is it important to understand how organisms are evolving in cities?

We are dramatically changing the way life kind of operates and as a result having a rapid and dramatic effect on the biodiversity on this planet. Understanding how cities, which are the main drivers of climate change and changes in our landscape are the driver of these biodiversity changes, understanding how it influences the evolution, is critically important to conservation of biodiversity on Earth.

The second reason is because it's becoming increasingly clear that we don't understand how the development of cities is influencing our own health. Evolution of organisms may play a part in some of these things like transmission of diseases, so if we have organisms like mosquitoes that are transmitting different diseases in urban areas, which is happening throughout the world, understanding how they adapt to those cities could be critically important for controlling pest populations and thus improving the health and well being of people that live in those cities.