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IN DEPTH

Cities causing genetic changes in plants, animals

Wild things may be changing at a genetic level to survive in modern cities

Sharon Oosthoek · CBC News · Posted: Feb 26, 2014 5:00 AM ET | Last Updated: February 26, 2014

A researcher holds an adult female tomcod taken from New York's Hudson River. Most of the river's tomcod now carry a genetic variant that makes them resistant to the ill effects of PCBs humans have dumped into the river. (Christopher Chambers, Northeast Fisheries Science Center, NOAA)

Plants and animals have a long history of acclimatizing to city living - think of raccoons and their expert pillaging of compost bins. But now biologists are beginning to see signs that something more fundamental is happening. They say wild things may be changing at a genetic level to survive cities and their polluting, habitat-fragmenting ways.

Fish in New York's chemically-laden Hudson River have evolved a genetic variation that gives them resistance to PCBs, for example. Birds nesting under highway overpasses in Nebraska

have developed shorter, more agile wings, allowing them to quickly swerve from oncoming traffic.

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And weeds occupying patches of earth surrounding sidewalk trees in France have evolved to produce fewer dispersing seeds, which travel on the breeze and fall uselessly onto concrete. Instead, they produce compact seeds that drop close to the plant where they can germinate.

On one hand, urban evolution is not new. Peppered moths in Britain changed colour from white to black in heavily polluted areas during the Industrial Revolution. White moths were picked off by predators while the black ones, camouflaged in a newly sooty environment, survived to breed more black moths.

What may be different this time is the number of city-dwelling creatures evolving to live in inhospitable habitats.

As cities grow in population and size, so too does their influence on the environment. One hundred years ago, two out of every 10 people were city-dwellers. Today, more than half of us live in cities that are spreading across more and more of the planet.

A small but growing number of scientists say urban evolution may be accelerating in tandem with that growth. And there could be tradeoffs that we are only beginning to glimpse.

It pays to downsize

University of Tulsa ecologist Charles Brown says he was surprised it took just 30 years for the cliff swallows in his study to evolve shorter wings that help them avoid traffic.

Since 1982, he and Mary Bomberger Brown, an ornithologist at the University of Nebraska–Lincoln, have been studying a group of birds that make their gourd-shaped mud nests under highway overpasses in southwestern Nebraska.

Cliff swallows are seen here nesting under a highway bridge in North Platte, Nebraska. They have evolved shorter wings, a life-saving attribute that allows them to take off quickly and be more agile in the face on oncoming traffic. (Charles Brown, University of Tulsa)

Over the years, they recorded a steady drop in the number of road-killed birds. This came as a surprise, because the colonies were growing and traffic had not declined. But as they compared the wing length of road-killed birds with those caught in nearby mist nets, they were in for another surprise - those caught in mist nets had noticeably shorter wings.

The researchers, who published their results last year in the journal Current Biology, believe net-caught birds avoided road deaths thanks to shorter wings that let them dodge traffic. Unlike their road-killed cousins, they survived long enough to pass down genes for shorter wings.

But is such urban evolution a necessary and positive development, or an evil to combat?

"It often results in an organism becoming better adapted to its environment," says Brown. "I suppose it's good if we are hoping that the organism persists."

Isaac Wirgin has a different view. He is a specialist in environmental medicine at New York University Medical Center and a lead author of a 2011 study in the journal Science on pollution-resistant tomcod fish in the Hudson River.

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>
> *- Isaac Wirgin, specialist in environmental medicine*

"In my mind, it's not a good thing," he says. "Usually evolution theory says if you adapt to something - like this resistance phenotype in tomcod - you're less good at reproduction or life expectancy, or you're more sensitive to other stressors."

While he did not delve into the potential cost of the tomcods' resistance to polychlorinated biphenyls (PCBs), a 2003 study by Duke University researchers found Atlantic killifish resistance to polycyclic aromatic hydrocarbons (PAHs) exacted a toll.

Killifish in Virginia's Elizabeth River developed a resistance to the acute toxicity, heart deformities and cancers linked to PAH exposure after a former wood treatment plant contaminated the river. At the same time, the fish developed a notably decreased tolerance of low oxygen levels - a periodic and natural stressor in many waterways.

In the case of the tomcod, there may also be wider ecosystem reverberations. From 1947 to 1976, two General Electric plants upstream of the mouth of the Hudson River released nearly 600,000 kilograms of PCBs into the water. Fish larvae exposed to PCBs often develop gross deformities such as missing jaws, which leads to starvation.

But Wirgin and his colleagues discovered in tomcod a natural variant of a gene called AHR2 that acts as a shield against PCBs.

The AHR2 gene gives instructions for building a particular protein in the fish. In order to do damage, PCBs must first bind to this protein. The gene's variant gives slightly different protein-building instructions, making it hard for PCBs to latch on.

Today, nearly all tomcod in the Hudson River carry this variant. Other populations of tomcod - in Canada and New England for example - do not.

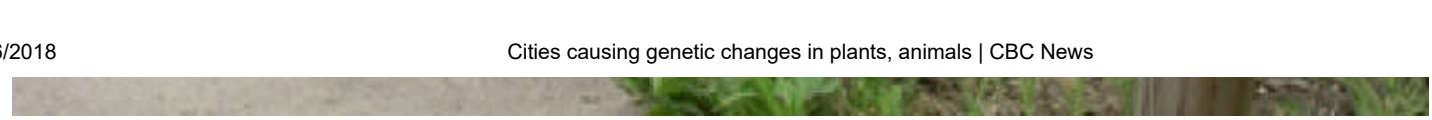
Yet the Hudson River tomcods' superhero powers of resistance could spell trouble for predators. They are a favourite snack for larger fish, which ingest PCBs with every bite.

There is no research on how this bioaccumulation affects tomcod-munching fish, but it suggests urban evolution has the potential to affect entire food webs.

Seeds of change

Meanwhile, Pierre-Olivier Cheptou, lead author of a 2008 weed study published in PNAS, highlights other implications.

He compared the common weed, Crepis sancta, occupying small patches of earth surrounding sidewalk trees in Montpellier, France, with those in the surrounding countryside.



Université de Montpellier evolutionary ecologist Pierre-Olivier Cheptou and his grad student collect seeds from weeds growing in patches of earth surrounding sidewalk trees in Montpellier, France. Their research indicates the plants have evolved to produce seeds that fall close by where they have a good chance of landing on soil, adapting to the lack of unpaved green space in the region. (S. Popy)

Cheptou and his colleagues found that over five to 12 generations, the urban weeds evolved to produce significantly more non-dispersing seeds than their country cousins.

Fewer dispersing seeds means reduced gene flow among already-isolated plants.

"What is selected in the short term, such as reduced dispersal in the city, may lead to extinction in the longer term because reducing dispersal means reducing new colonization," says the Université de Montpellier evolutionary ecologist.

So far, most studies of such adaptive changes have focused on species with short life spans - weeds, fish, birds, insects and worms. That's because the more generations that pass, the greater the opportunity for evolution.

Now scientists are turning their attention to longer-lived mammals.

Evolutionary ecologist Albrecht Schulte-Hostedde of Laurentian University is studying urban chipmunks to uncover potential adaptations in physiology, immune function and behaviour.

While it's too early for results, he says chances are good he will discover the evolutionary fingerprint of city living.

"On the one hand we can celebrate that some species are adapting and thriving," says Schulte-Hostedde. "On the other, we are left with reduced biodiversity in terms of the number of species that are capable of adaptation to urban environments."