I BET YOU DIDN'T KNOW...

Evolution of life in cities

Dr Alison Trew, PSTT Area Mentor and Website Resources Developer links **cutting edge research** with the **principles of primary science**

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Over half the human population of the world now lives in cities. Humans have built crowded settlements full of buildings, roads, and other things (infrastructure) necessary for life in the 21st century such as factories, power stations, power lines, dams and sewage systems. These places are called *urban* areas and the process of creating densely populated areas is called *urbanisation* (Figure 1).

Urbanisation and other human intervention (such as use of pesticides) can destroy or break up previously larger wildlife habitats. Urbanisation increases the amount of concrete and tarmac (impervious) surfaces, reducing the amount of rainwater that reaches soil and becomes available to animals, plants and microbes. Traffic and factories are responsible for higher temperatures, increased noise, light and air pollution. (Learn more about air pollution through PSTT's Air Pollution Research project). All these factors could affect whether an organism can live and reproduce successfully in its habitat.

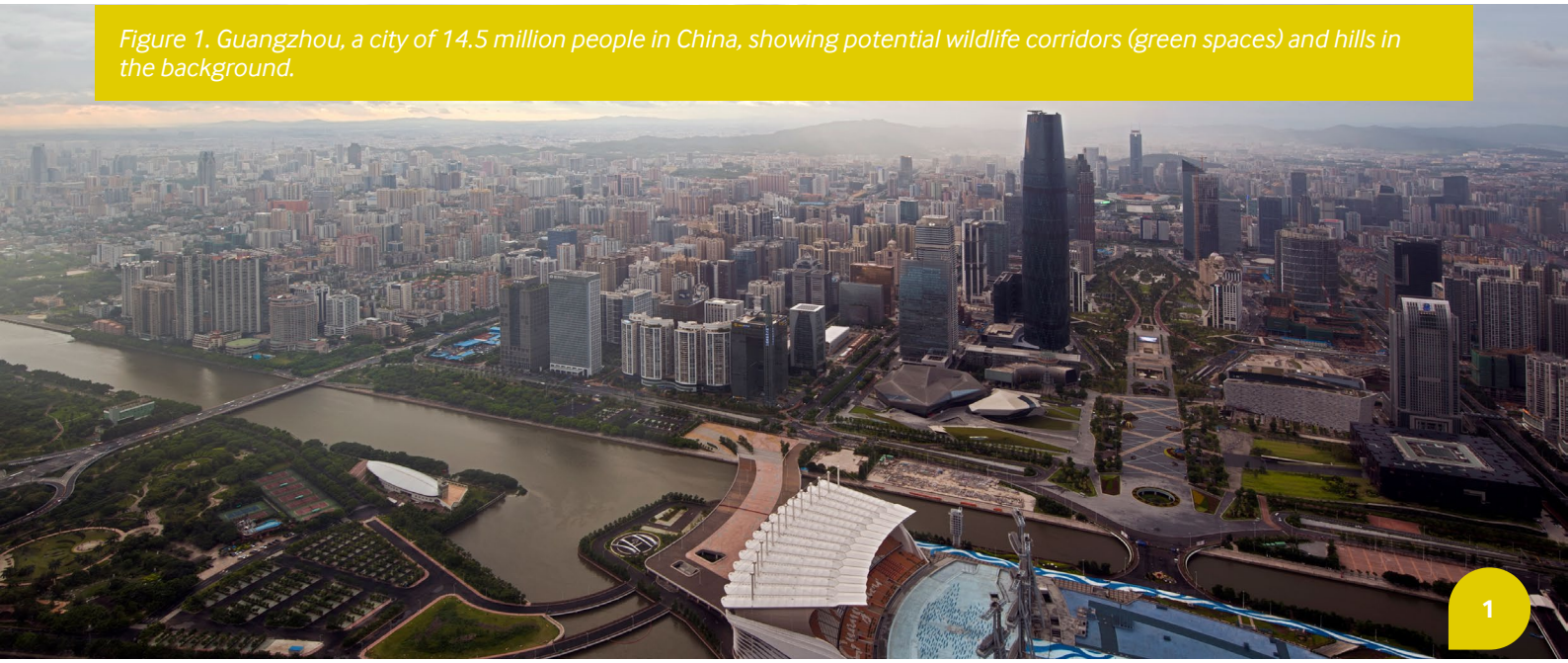
It is widely accepted that because of the variation that exists in any natural population, some individuals of a species will be better suited to their environment than others in the same population and they are more likely to survive and pass on their beneficial characteristics to their offspring. This is *natural selection*. Over time, the characteristics of the population may change. This process is known as *evolution*.

Humans and their activities on the planet are probably the biggest factors affecting evolution in other species. Scientists, Marc Johnson and Jason Munshi-South, have reviewed the work of many research groups to attempt to answer these questions:

How does urbanisation affect the evolution of animals, plants and microbes?

How does evolution in urban areas affect ecosystems and human health?

Figure 1. Guangzhou, a city of 14.5 million people in China, showing potential wildlife corridors (green spaces) and hills in the background.



In their paper, the scientists referenced 152 studies of urban evolution carried out by other scientists and provide us with some answers. This article is a summary of some of their findings.

How does urbanisation affect evolution of animals, plants or microbes?

Urban pollution, for example air pollution, increases concentrations of cancer-causing (carcinogenic) compounds. Such compounds could trigger mistakes (*mutations*) in organisms' DNA sequences that could lead to changes in their inherited characteristics. Primary teachers often give the example of the melanic peppered moth when teaching about evolution: before the Industrial Revolution in Europe, this moth had light coloured wings that effectively camouflaged them against light-coloured trees (Figure 2A). With coal pollution in cities (leading to blackened buildings), there was an increase in a previously unknown black-bodied moth (Figure 2B) and a decrease in the white-bodied form due to bird predation. The review explains that in 2016, scientists confirmed that the appearance of the black moth was a result of a mutation (an insertion of a large DNA sequence) around 1819.

Figure 2. The melanic peppered moth.
(A) The white-bodied form (Biston betularia f. typica).
(B) The black-bodied form (Biston betularia f. carbonaria).

Urbanisation can also be responsible for reducing the size of populations of animals, plants and microbes. This can happen when the original larger natural habitat has been reduced or destroyed during the city's construction, or because a very small number of individuals from a larger countryside (rural) population have migrated into the city. In these small, newly established urban populations, the difference in DNA among the individuals, known as *genetic variation*, can be much less than in nearby rural populations. The scientists give examples of studies that have shown this: red foxes living in Zurich (Switzerland), blackbirds in cities across Europe, and a mosquito that separately colonised the underground systems in London, Chicago and NYC.

Barriers such as roads and manicured green spaces may restrict animal movement and therefore reduce the transfer of genetic variation from one population to another, known as *gene flow*. In other words, genetic information from different populations cannot mix. Over generations, there will be greater genetic differences between the different populations on either side of the barrier. The scientists give examples of studies that have shown this: the common wall lizard, sparrows and the bumble bee. In contrast, wildlife corridors that increase gene flow may increase genetic diversity within populations and reduce differences between populations.

How quickly do populations adapt to urban environments?

There is evidence that rapid adaptation has enabled some native species to live successfully in urban areas. A study of the peppered moth (described above) was the first to suggest that urbanisation can affect natural selection on populations. In 2008, a study showed that finches that ate larger, harder sunflower seeds from birdfeeders in a US city had longer and wider beaks than nearby desert finches who ate smaller, softer food. The change in diet caused selection in urban bird populations for beaks with a stronger bite force. In 2016, a study showed crested anoles (Figure 3) in three cities of Puerto Rico had longer limbs and more scales (lamellae) on their toes compared with lizards in nearby forest habitats. These characteristics are thought to increase the lizards' movement across artificial (possibly smoother) surfaces in cities and suggests that natural selection of populations is taking place.

Figure 3. (A) Puerto Rican Crested Anole.
(B) The underside of a gecko's foot showing scales (lamellae) on the toes.

Although an enormous amount of studies were reviewed, the scientists concluded that there are still three unresolved questions:

1. How frequently do populations adapt to cities?

The authors of the review point out that most studies examine only a few populations in one city and have been carried out in temperate regions (not tropical, arid or forest regions). Sampling multiple cities across the world will be important in increasing our understanding.

2. Will urban evolution be beneficial to conservation and human health?

If rare and endangered species can adapt to urban environments, this could help conservation efforts. Examples of this to date are found in peregrine falcons, which now nest in cities, prairie dogs that favour cities and cliff plants that will grow on urban substrates. On the other hand, if some species cannot adapt to survive in urban habitats, there could be a detrimental effect along the food chain for other species.

Humans have lived with head lice and body lice for centuries. Today, head lice can be treated with specialist shampoos containing pesticides but evolution of insecticide resistance in contemporary head lice could be a problem in the future. Some rats have evolved a resistance to widely used warfarin pesticides. In these cases, rapid adaptation has allowed human pests to spread more rapidly.

3. Can we design cities that are more sustainable?

Given the speed and scale of urbanisation around the world, it is likely that new urban populations of a wide range of species will become established in the future. Understanding more about how urbanisation affects the evolution of species might mean that we could design homes and cities that will control population sizes of some species. This may reduce the spread of human pests and diseases and prevent the spread of pesticide resistance. There is more research to be done.

GLOSSARY

Ecosystem
a community of living organisms (plants, animals and microbes) in a particular area.

Evolution
the process of change in populations over time because of natural selection.

Gene flow
the movement of genes from one population to another.

Genetic variation
the differences in the DNA sequences between individuals within a population.

Mutation
a change in the DNA sequence.

Natural selection
the process where those organisms better adapted to their environment survive and pass on their beneficial characteristics to their offspring.

Urbanisation
the process of creating densely populated areas.

The research paper that generated this work was:

Evolution of life in urban environments.

By Marc T. J. Johnson & Jason Munshi-South.

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