How DNA is helping us fight back against pest invasions

May 28 2015, by Steven Bourne

Spot the difference? Credit: Anders Sandberg/flickr, CC BY-NC

They are the original globe trekkers. From spiders bunking along with humanity's spread into south-eastern Asia, to sea squirts hopping on military craft returning after the Korean War, invasive species have enveloped the globe.

These species outcompete native ones for resources and also cause immense environmental damage, for example by eating native species and their young, or by introducing parasites and diseases.

Their largest impact, however, is economic. The estimated annual cost of invasive species to the UK and Ireland is £2 billion. This includes the cost of damage from all invasive animal and plant species to sectors such as tourism, business, human health and agriculture.

The cost of controlling invasive species is also huge. Eradication, if possible, may cost millions of pounds. This cost increases as the population becomes bigger, and a late-caught invasion can cost thousands of times more to control than one that was caught early on. Aside from some small technical differences, this model can be applied across all invasive species.

Environmentally, they pose a significant threat to global biodiversity by competing with other species and altering the environment, for example by blocking waterways or accelerating erosion.

Conventional monitoring techniques, such as checking and photographing the bottom of recreational boats for potential invaders, are not robust enough to handle this threat. Many invasive species also look similar to natives and can also confuse detection. Fortunately, a potent tool is available that lends well to management of invasive species: analysis of their DNA.

Decoding genetics

In the 1970s Frederick Sanger devised a method of automatically reading and sequencing DNA. Sanger sequencing allowed biologists to study the genes (the stretch of DNA coding for a specific trait that is passed down through generations) of invasive species and piece together much information about their genomes (the complete sets of all their genes and DNA) and evolution.

Genetic techniques also enhance management of invasive species. They are essential for informed sustainable policy decisions.

For example, comparing genetic variation within and between populations allows biologists to understand how invading species spread, mix and compete with native species. This has given researchers a better understanding of the routes that invasive animals such as sea squirts, ladybirds and invertebrate pests took when colonising new areas.

Biologists can also use genetic techniques to catch invasions earlier by detecting animals' DNA in the environment from shed material such as skin or urine. This was demonstrated by detecting the DNA of an invasive bullfrog in French ponds much earlier than the invasion would otherwise have been noticed.

Genomic leap forward

Over the past decade, genetics has slowly been caught by the study of genomics, which offers a much more comprehensive view of DNA because it involves sequencing the entire genome rather than just a number of genes. Studying the genome enables us to analyse variability between invasive populations in greater detail and sensitivity.

Since next-generation sequencing technology drastically reduced the price of DNA sequencing in the mid-2000s, scientists have been able to explore hundreds of thousands of regions of DNA, rather than the tens used in genetic studies. Genomics has also helped to create new tools to assist our study of invasive species.

Studying organisms' full genomes also introduces an extremely powerful method to study the evolutionary history of invasive species. It allows biologists to distinguish the neutral DNA changes that all organisms undergo but that don't spread through a species, from positive changes that improve an organism's chances of survival and reproduction and so do spread.

This positively-selected evolution drives the fast adaptation of invasive species. So by understanding the effects of positive evolution, we can predict how species might adapt in the future.

Genomics has yet to realise its potential in invasion biology, but invasion genetics is slowly progressing into invasion genomics. Both disciplines offer a cost-effective solution to the monitoring and management of invasive species. For example, a programme exists in the US for early detection of the invasive Asian Carp in the Great Lakes. This early detection, which involves sampling water to check for shed DNA material, will save significant sums in managing the invasive fish.

If more widely and effectively employed, genetic and genomic techniques have the potential to save both natural environments and the public purse from the environmental side-effects of globalisation.

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