With biotech on the brink of resurrecting extinct species, is this a new age for conservation, wonders **Sandrine Ceurstemont**

Extinct is not forever

KATSUHIKO HAYASHI is playing God. In his lab at Kyushu University in Fukuoka, Japan, he recently created eight baby mice using eggs made from reprogrammed mouse skin cells. Now he's working his magic on the northern white rhino, a species so endangered there are just three individuals left, all with reproductive problems. And he has even bigger plans: he wants to use the technique to resurrect extinct animals.

De-extinction isn't a new idea. But where early attempts owed more to *Jurassic Park* than to science, Hayashi and others are taking a more high-minded approach. They look at the fast-moving field of biotechnology and see its conservation potential. "Many animals are gone because of human error, so we need to use technology to recover them," he says.

He has a point. With 100 or so species disappearing from the planet every day, we are living through one of the biggest mass extinctions ever. And the causes – from poaching to pollution to climate change – are down to us. At the same time, cutting-edge biotechnology, including genome sequencing, cloning and gene-editing tools like CRISPR, is allowing us to manipulate life. We are now on the verge of being able to undo extinctions, and researchers are racing to get there first. But while some foresee a thrilling new age of conservation and are urging conservationists to embrace it, others are horrified by the prospect of high-tech meddling with nature.

Even de-extinction's greatest advocates admit that it is expensive and risky, so the ›

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Is the great auk worth the expense of de-extinction?

"De-extinction technologies won't so much resurrect species as create new life forms"

VINCENT J. MUSI/NATIONAL GEOGRAPHIC CREATIVE

GOOD BREEDING

The aurochs, a large ancestor of domestic cattle, died out because of habitat loss and overhunting. Its last known sighting was in 1627,but Ronald Goderie from the Tauros project in Nijmegen, the Netherlands, and his team are bringing it back, at least in spirit. Rather than using genetic engineering, they are cross-breeding existing primitive bovine breeds with the same key traits as the aurochs, such as a slender build and forward-pointing horns. Goderie thinks this will spawn an animal better suited to modern times. "Living breeds have adaptations and genetic diversity that you might miss with the genetic engineering approach," he says.

Small herds of mock aurochs, dubbed tauroses, have already been released into the wild in a few European countries. Now Goderie and his team are refining their prototype by comparing its genome with that of the aurochs, which was published in 2015. They also plan to identify which genes in the aurochs are responsible for its distinct features, and selectively breed tauroses with the same ones.

reasons for pursuing it need to be well thought out. The biggest problem may be deciding which species to bring back. One approach is to focus on charismatic species. For example, geneticist George Church at Harvard University thinks he is just two years away from creating a hybrid mammoth-elephant embryo. But if conservation is the rationale, then charisma is less important than usefulness. "What I am most concerned about is functional loss," says ecologist Douglas McCauley at the University of California, Santa Barbara. "If a species with an irreplaceable role disappears, it can have a cascading effect and drive other species to extinction too."

Worthy candidates

By this yardstick, the moa is a good candidate for resurrection. A massive flightless bird once abundant in New Zealand, it became extinct about 600 years ago, largely as a result of hunting and deforestation. That has had a knock-on effect, with plants that relied on the bird to disperse their seeds still struggling to survive. So the moa performed an irreplaceable ecological role. But there are two further criteria to heed when deciding which de-extinctions to prioritise, according to McCauley and his colleagues. They argue that species that died out in the past 50 years should take precedence because, in most cases, an ancient animal would no longer fit in as the environment would have changed too much. In addition, they say, we should focus on species that can be restored to levels that can boost the functioning of the ecosystem.

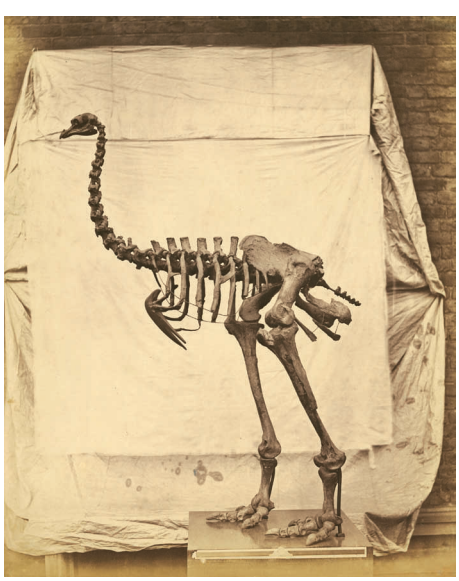
Although the moa became extinct centuries ago, it could tick one of these boxes. David Iorns, founder of the Genetic Rescue Foundation in Palo Alto, California, and his colleagues are currently working on sequencing its genome as a first step to de-extinction, and they think there is still suitable habitat for a reintroduction. "Its native environment remains sparsely populated," he says. However, the prospect of creating a good-sized population of moas is slim, not least because even if its genome can be recreated, the bird is so genetically distinctive that finding a surrogate animal to gestate the embryo would prove tricky.

Far more promising is the lesser stick-nest rat. Believed to have gone extinct in the past few decades, it played a crucial role in the Australian desert, where it used sticks to build impressive nests. Because the landscape is mostly flat, the structures – up to 3 metres long and a metre tall – became home to other animals too, from insects to reptiles. "They were like biodiversity high-rises," says McCauley. And the rat's rapid gestation and short lifespan make it a relatively easy target for resurrection. "With an aggressive breeding programme, an abundant population could be built up in five to 10 years," he says.

Nobody is working on the lesser stick-nest rat just yet, though. Indeed, de-extinction researchers keep identifying new risk factors that take candidate species out of the running. One is highlighted by plans to recreate the gastric brooding frog – the only known animal to turn its stomach into a womb, from where it spewed out its froglets by vomiting. Simon Clulow at the University of Newcastle in Australia aims to recreate the frog using DNA from cells found in a freezer. The idea is to transfer the DNA into another frog's egg that has had its nucleus removed – a method known as reproductive cloning. In 2009, the technique recreated an extinct subspecies of the Pyrenean ibex, a mountain goat. The animal had damaged lungs and only survived a few minutes, but the technology has improved since then. Nevertheless, if Clulow is successful he will not return his gastric brooding frog to the wild because it was probably wiped out by chytrid fungus, which continues to kill off amphibians worldwide. "We need to address the cause of its decline or it will just disappear again," he says.

And there are yet more challenges facing high-tech conservation. One of the biggest

Without moas to disperse their seeds, some of New Zealand's plants are struggling to survive



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