https://doi.org/10.1038/s41477-023-01368-2

No resurrection without preservation

Although the resurrection of extinct species may seem like the stuff of science-fiction, it could have practical benefits for conservation. But first we must secure the genetic diversity that we have left.

In January of this year, Colossal Bioscience (a company founded in 2021 by George Church and Ben Lamm) announced its intention to 'de-extinct' the dodo. This is just the latest of a number of high-profile projects to bring an animal species 'back from the dead'. Colossal itself has already set up initiatives to produce woolly mammoths and thylacines, a type of marsupial wolf the last known individual of which died in a zoo in Tasmania in 1936.

Practical attempts at de-extinction were first prompted by the birth of Dolly the sheep in 1996, the first mammal to be successfully cloned from adult somatic tissue. At this time, the Pyrenean ibex (*Capra pyrenaica pyrenaica*) was critically endangered, with a single population made up of a handful of individuals existing in Ordesa National Park in Northern Spain. In 2000, the last known individual (a female called Celia) died; however, in the previous year she had been captured, and skin biopsies were taken and preserved prior to her rerelease. Using similar techniques to the cloning of Dolly, cloned ibex embryos were created. This kind of cloning has very low success rates, but in 2003 a single female Pyrenean ibex was born (having been implanted in a surrogate goat), making this the first animal species to undergo 'de-extinction'. This was however very short-lived, as the calf died only a few minutes after its birth.

Even if the calf had lived, it would have proved very difficult to rebuild a self-sustaining population from her; no male Pyrenean ibexes existed to breed with. Were a male somehow produced by cloning of the available female tissue, any resulting population would have had a very restricted gene-pool and would thus be likely to suffer from low disease resistance and high incidence of genetic disorders.

This North American black-footed ferret (*Mustela nigripes*) currently faces this problem. These ferrets were once common throughout the central prairies of North America, but the population diminished until 1987 when the species consisted of 18 individuals who had been trapped and were entered into a captive breeding program. The program has been a great success with well over a thousand individuals now living in the wild, but the entire species is heavily inbred, tracing its ancestry to the offspring of just seven founders. Fortuitously, in the 1970s, skin tissue had been taken and cryopreserved from a male and a female black-footed ferret, both of which were unrelated to any of the seven ferrets that have sired the current population. In 2020, a ferret called Elizabeth Anne, cloned from the preserved female tissue, was born. It is hoped that this female will help broaden the ferret gene pool.

The tissue from which Elizabeth Anne was cloned had been held in San Diego Zoo's 'Frozen Zoo', which holds tissue samples, sperm, oocytes and embryos from nearly a thousand taxa. This is just one biobank holding samples from threatened, endangered and even extinct species in support of conservation efforts. The UK has a network of 'CryoArks' at various zoos and Universities, the European Association of Zoos and Aquaria maintains a biobank over four different sites and international organizations such as Frozen Ark co-ordinate banks worldwide. All such initiatives are striving to safeguard the genetic diversity of the animal world in the service of current and future conservation.

If this sounds at all familiar it may be because plant scientists have been routinely banking material for very similar reasons for decades. Of course, most plants have fewer difficulties with regeneration than mammals, and seeds have an inherent longevity far beyond isolated animal reproductive tissue. For example, 'extinct' Judean date palms (*Phoenix dactylifera* L.) have been grown from seeds collected from archaeological sites that were dated to as long ago as the fourth century BCE. When sequenced, their genomes showed that the loss of this species took place gradually due to increased crossing with related plants from other parts of the Mediterranean[1].

Botanical gardens routinely preserve 'extinct in the wild' plant species as living specimens, seeds or preserved tissue. The constant development of new methods of storage involving desiccation and cryopreservation, as well as experience in resuscitating plants from these preserved tissues, means that an increasing percentage of floral diversity is 'saved' in seed banks throughout the world. The ultimate backup of these banks is the Global Seed Vault on Svalbard in the Norwegian arctic.

Many plant species are not currently amenable to seed banking[2], but the Svalbard seed vault has already proved its worth in rebuilding the collection of the International Center for Agricultural Research in the Dry Areas (ICARDA), following its destruction by the war in Syria in 2014 (ref. [3]). More than 80% of the original collection was duplicated in Svalbrd, and using this, ICARDA was able to resume its operations from new premises in Morocco and Lebanon. In fact, while candidates for de-extinction in animals are very limited, the extensive collections of seeds and tissues in herbaria make choosing the 'best' from a multitude of potential candidates for resurrection a substantial problem[4].

Headline-grabbing claims about recreating extinct charismatic megafauna aside, the preservation of genetic diversity by any means available is crucial in maintaining a sustainable planet, both by preserving wild ecosystems and by providing a resource for agricultural improvement with crop wild relatives. Botanists have pursued this for decades, so it is good to see our animal-focussed colleagues beginning to catch up.

Published online: 22 February 2023

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