AUGUST 2023

BIOMEDICAL SCIENCE JOURNAL FOR KIDS

Why is it so hard to bring back extinct species?

Authors:
Tom Gilbert, Christina Lehmkuhl Noer, Jianqing Lin, and others
Associate Editors:
Daniel Watkins and Alexandra Appleton

Abstract

De-extinction is the science of bringing back extinct species. But it's very challenging. Scientists are testing out lots of different ideas. One promising idea is to use genetic engineering to piece together the DNA of an extinct species. We analyzed old, fragmented DNA of the Christmas Island rat, which went extinct about 100 years ago. For an extinct species, the only option is to use the genome of a similar, living species as a reference. By comparing DNA fragments to the reference, you can put the pieces in the right order. We used brown rats as a reference. Unfortunately, we found that some of the genes of the extinct species can't be recovered. This means that an animal brought back by genetic engineering wouldn't be an exact copy of the extinct species.

Introduction

Imagine if you could visit a wildlife refuge and see a wooly mammoth or a dodo! **De-extinction** is the effort to bring back **extinct** species such as these. Many animals have gone extinct due to human activities, like overhunting or habitat destruction. An entire **ecosystem** can be damaged when just one species disappears. If we can bring an animal back from extinction, then it's possible that some of that ecosystem could be restored.

Scientists are testing out lots of ways that de-extinction might be possible. One possible method is **cloning**. Cloning is when the DNA from one animal is placed into the **egg cell** of another animal. But this method only works if there are still intact cells from the extinct animal available. Scientists are trying this method with the Pyrenean ibex, which went extinct in January 2000. Another idea is **back-breeding**. The quagga is a subspecies of zebra that went extinct in the 1880s. Since it shares almost all its **DNA** with modern zebras, it may be possible to selectively breed zebras until they look the same as the extinct quagga.

Another option is **genetic engineering**. Using techniques from ancient DNA (**aDNA**) analysis, it may be possible to **sequence the genome** of extinct animals. Scientists could then use special tools to edit the DNA from a closely related **reference species** to match the DNA of the extinct species. This DNA would be placed inside the egg and sperm cells of the reference species. But how close would the new animal be to the extinct animal? That's what we wanted to find out!

The quagga (*Equus quagga*) – an animal related to horses and zebras – went extinct in 1883.

Methods

Our study focuses on the Christmas Island rat. We used the common brown rat as a reference species for DNA comparison. The brown rat and Christmas Island rat are closely related to each other (Fig.1). So this represents a "best-case scenario" for genetic engineering. It also helps that brown rats are studied in labs a lot. We thus have well-tested methods for studying and editing their DNA.

We extracted DNA from two preserved Christmas Island rats from a collection at the Oxford University Museum of Natural History. We used a small piece of the dried skin from each rat. The samples were collected between 1900 and 1902. DNA breaks apart as it gets old, so we expected the Christmas Island rat DNA to be in many small fragments. We used methods from aDNA analysis to multiply the amount of DNA in each sample. We then read the tiny pieces of fragmented Christmas Island DNA and lined them up with the brown rat genome for reference.

We also used the same methods with the genomes of other rat species. Other labs sequenced the genomes of those species and shared them with us.

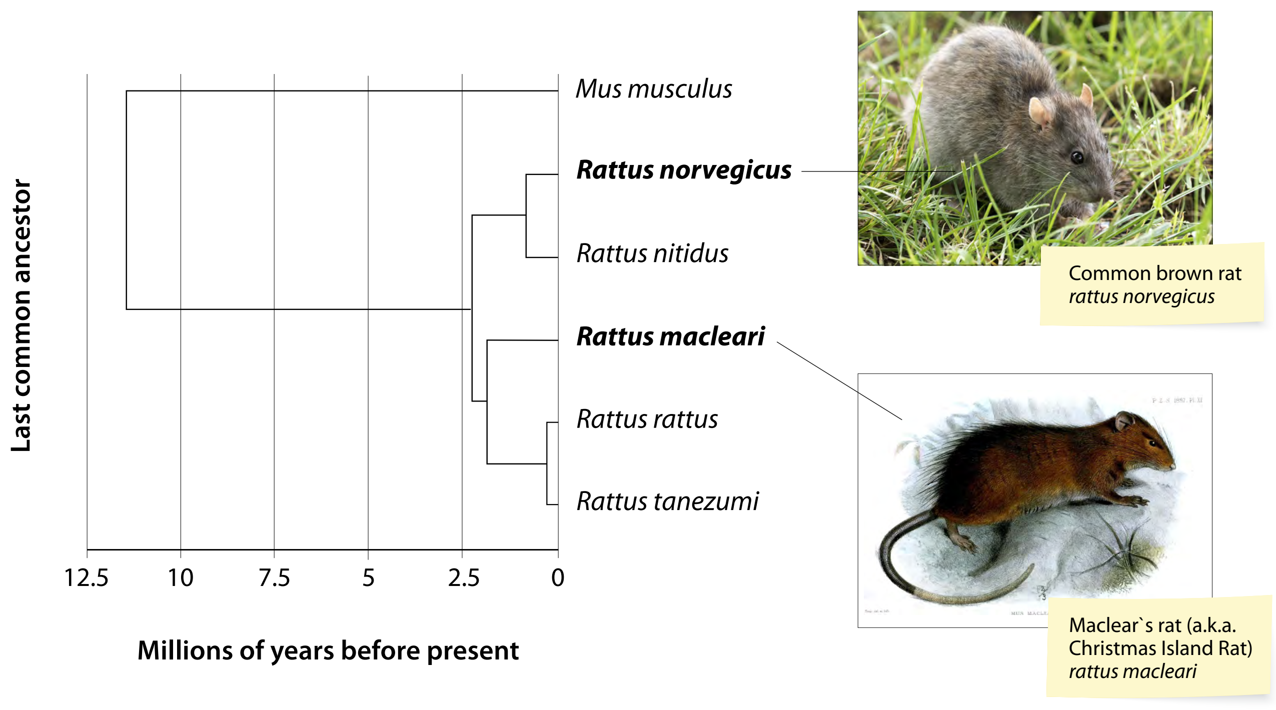

Figure 1: The last common ancestor of brown rats (*Rattus norvegicus*) and Christmas Island rats (*Rattus macleari*) lived about 2.3 million years ago. For humans, that's a long time, but it's a short time when we are talking about evolution! For comparison, humans and chimpanzees' last common ancestor lived between 7 and 8 million years ago. **Photo:** Zeynel Cebeci, CC BY-SA 4.0.

Results

We were able to recover 95% of the Christmas Island rat genome, which sounds like a good amount (Fig.2). But we were surprised to find that the missing 5% of the genome wasn't random. We recovered the parts of the genome that give the Christmas Island rat its distinctive long black hair and long whiskers very well. Yet there were some genes that we were unable to recover at all. Large parts of the genes related to the rat's sense of smell and immune system were missing.

We then looked at the genome data from three other rat species. We found that we ran into the same kind of problem with all of them. This tells us that the imperfect match is due to differences between species, and not problems with the technology.

The number of poorly recovered genes is small compared to the total number of genes. Why is it important to know that some genes aren't recovered well?

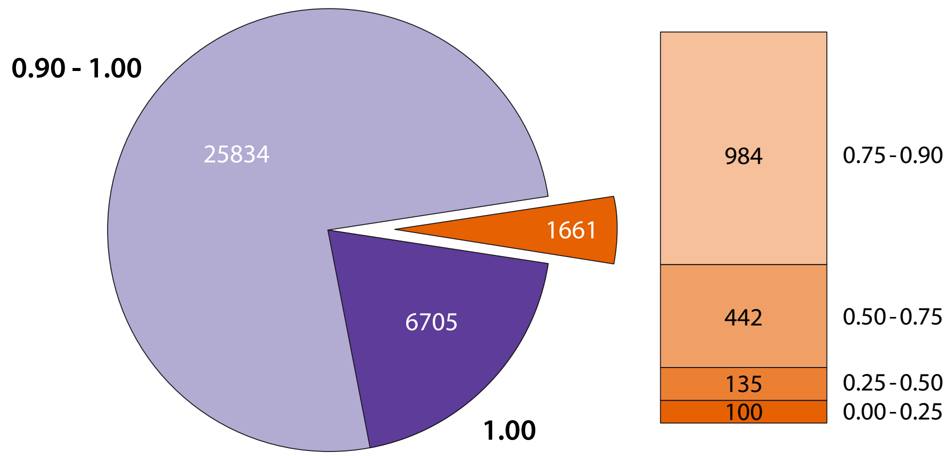

Figure 2: The number of genes found at different coverage levels. Coverage level describes how well each gene was recovered. The closer the number is to 1, the better the reading. At coverage level 0, none of the DNA from a gene was able to be read and edited. The numbers in each region show the number of genes at each coverage level. We found that there were 100 genes that had very low or no coverage.

Discussion

We wanted to know if we could recover enough of the genome to bring back Christmas Island rats. We were able to recover a lot, but the missing parts were important! We now know that for most extinct species it will not be possible to bring back an exact replica via genetic engineering. They will always have some traits of the extinct species and some traits of the reference species.

That doesn't mean that de-extinction projects are a scientific dead end, though! Many scientists hope that they can introduce a new species to fill a **niche** left by an extinct species. A healthy ecosystem needs a variety of species living together. Human actions have made it difficult for many animals to survive. Overhunting, cutting down forests, and draining marshes are harmful. Many species have become extinct, leaving important roles in habitats unfilled. So, de-extinction may be able to introduce new species to take on these ecological roles.

Conclusion

It is exciting to see the different ways that de-extinction could happen. But one thing is very clear: it is much easier to keep a species from going extinct than it is to bring a species back! That's why it's so important to protect and conserve endangered species. Visit wildlife reserves in your corner of the world to learn more about the animals in habitats near you. By helping to care for the environment, you can help keep animals from going extinct.

Acknowledgement: This article's adaptation was supported by the GM Foundation.

Glossary of Key Terms

Ancient DNA (aDNA) - old DNA that has degraded and has broken into pieces. How degraded the DNA sample is depends on many variables, including age and environmental conditions. For example, DNA from mammoths frozen in permafrost can last a lot longer than DNA from animals in hot, humid climates.

Back-breeding - selective breeding of a species to re-introduce a trait that was once common in the species but is no longer present.

Cloning - producing an organism with an exact copy of another organism's genome.

De-extinction - the science of bringing back extinct species, or at least bringing back traits of extinct species.

DNA - the material inside cells that contains the genetic instructions for the development and function of a living thing. The DNA inside each of an organism's cells contains a blueprint for making it what it is.

Ecosystem - a community of living organisms and their physical environment.

Egg cell - the female reproductive cell.

Extinct - describes a species with no more of its kind on Earth.

Genetic engineering - changing the genome of an organism using technology.

Niche - the position or role of a species in its habitat.

Reference species - a living species that is closely related to the extinct species.

Sequencing the genome - reading the genetic information in a species' DNA.

Check your understanding

1. Why do scientists like us want to try to bring back extinct species?
2. What methods have been proposed, and what is a limitation of each method?
3. In this study, why would a species introduced by de-extinction technology not be exactly the same as the original species?
4. Imagine that you are choosing the projects for a science lab to work on. Would you rather work on inventing technology for de-extinction, or work on preserving a living species? Why?
5. Working in a pair or a small group, do some research about a current endangered species and create a poster that outlines why they are in danger and what can be done to help.

REFERENCES

Jianqing Lin, David Duchêne, Christian Carøe, Oliver Smith, Marta Maria Ciucani, Jonas Niemann, Douglas Richmond, Alex D. Greenwood, Ross MacPhee, Guojie Zhang, Shyam Gopalakrishnan, and M. Thomas P. Gilbert (2022) *Probing the genomic limits of de-extinction in the Christmas Island rat.* Current Biology.
https://www.sciencedirect.com/science/article/pii/S0960982222002494

Scientific American: A 'de-extinction' company wants to bring back the dodo
https://www.scientificamerican.com/article/tech-company-invests-150m-to-bring-back-the-dodo/

BBC: How extinct animals could be brought back from the dead
https://www.bbc.com/future/article/20230113-how-extinct-animals-could-be-brought-back-from-the-dead