

I BET YOU DIDN'T KNOW...

Red squirrels adapt to food they eat

Red squirrels (Figure 1A) used to be common across Great Britain, but their numbers started to decline in the 1920s. Today, red squirrel populations are only found in a few areas of Great Britain. Possible reasons include a loss of woodland habitats, the introduction of the eastern grey squirrel (Figure 1B) to England in the late 1800s, and squirrel pox virus. Now that the remaining British red squirrel populations are isolated from each other, scientists are interested in finding out whether there are any differences between them. This might help us to understand why some populations have survived when others are now extinct. It might help *conservationists* to protect threatened populations and to reintroduce populations in new regions successfully.

Questions children might like to consider:

- Why do you think numbers of red squirrels have decreased?
- What might happen if red squirrels become extinct?
- Do you know of any other endangered species in this country or elsewhere?

How are red squirrels and grey squirrels different?

Red squirrels (*Sciurus vulgaris*) and grey squirrels (*Sciurus carolinensis*) are different species (Figure 1). This means that they cannot produce baby squirrels (offspring)

Figure 1. A, Red squirrels have a reddish-brown coat with a pale underside and large ear tufts. B, Grey squirrels have a silver-grey coat with a brownish face and pale underside and smaller ears.



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together. Red squirrels are *native* species which means that they occur naturally in Great Britain and they are usually found in coniferous woodland or heathland. They like to eat hazelnuts, pine cones and seeds. Grey squirrels are *native* to the oak-hickory woodlands of the eastern United States. They are much larger than red squirrels and are commonly seen in woods, gardens and parks across the UK. They also like hazelnuts but they will eat other seeds such as acorns.

Questions children might like to consider:

- If grey squirrels are not native to Great Britain, how did they arrive in the UK?
- How was the population established?

What did the scientists want to find out? Why?

Because UK red squirrel populations live in different habitats such as coniferous woodland, moorland and heathland (Figure 2), they could be eating different types of foods. Scientists have shown that the structure of an animal's jaw can develop differently depending on the animal's diet. In areas where only hard food is available (e.g. Northern Scotland where it is mostly pine cones), squirrels with stronger jaw muscles will be more likely to survive and pass those stronger muscles on to the next generation. In areas where food is less hard (e.g. Formby where peanuts are provided), it will be less important to evolve stronger jaw muscles and the associated bone structures.

Dr Philip Cox and his colleagues wanted to find out whether the separated UK populations of red squirrel had jawbones that were *morphologically* different from each other - this means differences in their appearance such as the size or shape. And, if differences were found, they wanted to know how this might affect the squirrels' bite force.

Figure 2. A, coniferous woodland is characterised by evergreen trees with needles rather than leaves and cones rather than flowers. B, heathland and moorland habitats are covered by low-growing woody plants such as heather. Moorland refers to heathland in mountainous regions and is generally cooler and damper.



Questions to discuss with children:

- What foods do you think would be available for squirrels living in different habitats such as coniferous woodland, heathland, or moorland – see Figure 2?
- What type of teeth/jaw do you think the squirrel would need to eat different types of food such as hazel nuts, acorns, small seeds, fruit or berries?

How did the scientists compare squirrel jawbones?

258 red squirrel skeletons were obtained from the National Museums of Scotland with information about where each one had come from (Figure 3). None of the animals were killed especially to be part of this study or to go into the museum collections. They all died in the wild and were collected by researchers and volunteers. Half of the lower jawbone (*mandible*) was photographed and 12 points on each jaw image were identified (Figure 4). Using computer software to measure the distances between these points, the sizes of the squirrel mandibles could be compared. By looking closely at the distances between the points where the three main jaw-closing muscles are attached, the scientists also calculated the ability of those muscles to produce forces needed for biting.

Figure 3. A, Map showing British red squirrel populations analysed in this study. B, Table showing key for map and the number of samples of red squirrel skeletons from the different regions. *Red squirrels are now extinct in Thetford.

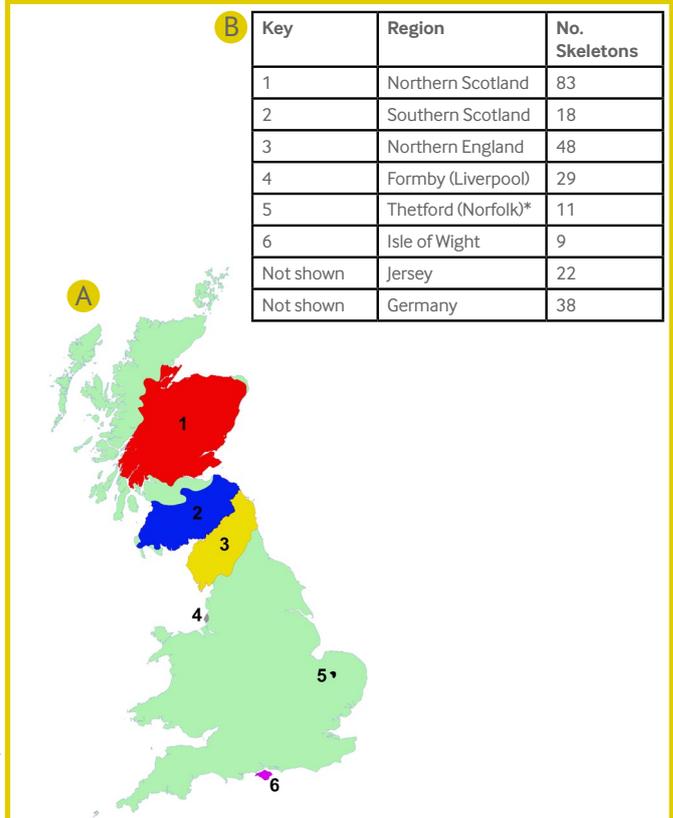
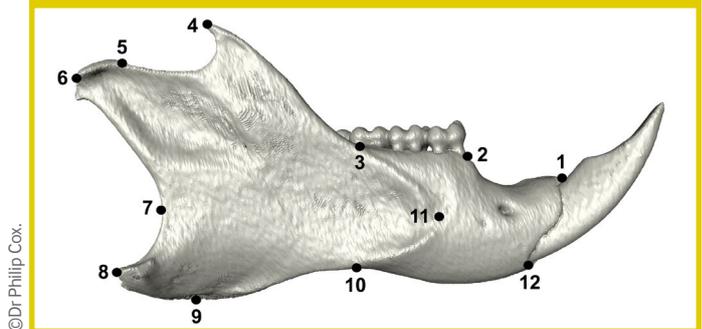


Figure 4. Image of the right side of the lower jawbone of a red squirrel (side view) showing the 12 landmark points used by scientists to compare size and shape of different jaw bones.



How do the jawbones of red squirrel populations differ?

The Formby and Jersey populations of red squirrels had a shorter jaw-closing muscle (the *temporalis* muscle). You also have a temporalis muscle – you can feel this muscle move if you put your fingers on the sides of your head, just next to your eyebrows, and clench your teeth. This muscle was also shown to be weaker in the Formby and Jersey populations than in the other red squirrel populations. These populations may be less efficient at incisor gnawing than the other squirrel populations. This is interesting because the Formby and Jersey populations receive a lot of extra food from humans, such as peanuts.

The scientists suggest that differences in diet could have a role in causing the differences in the structure and function of the red squirrel's jawbones.

Why are these results important?

These results are valuable for the conservation of red squirrel populations in Britain for two reasons:

Providing extra food has been really important in the survival of some red squirrel populations. However, feeding squirrels with softer food could be an issue if the squirrels move to another site where seeds and nuts are harder.

Methods to protect species in the wild often rely on the introduction of new individuals that have been bred in captivity. If diet can affect the size and strength of the jawbone, then breeders must provide a diet that is similar to what is available in the release sites.

What do you think the scientists should investigate next?

This research only looked at the structure of the lower jawbone so further studies might include investigations on the skull. Dr Cox and his team are going to use chemistry to analyse the squirrel jaws and teeth to see what those squirrels were eating when they were alive.

The skeletons used in this study were collected between 1994 and 2006 which is not a long period when looking at changes in populations. Dr Cox's research group will collect more specimens from a longer timeline.

As computer software is always being updated, scientists will have better modelling systems in the future. Dr Cox and his colleagues will use a special kind of computer modelling (the same method that is used to virtually crash-test cars) to understand how hard squirrels can bite.

There is uncertainty about the origins of some of the British populations of red squirrels. For example, the Jersey population of red squirrels was probably brought in from France and southern England in the 1880s and the Formby population was brought here from Europe (possibly Scandinavia) in the first half for the 20th century. To learn more, scientists plan to carry out genetic studies to look at differences in the DNA of different populations.

Scientists will want to combine all these approaches to understand more about how red squirrel populations adapt to different habitats. What they find out might help increase populations in Great Britain and might inform conservation methods for other threatened species. You might like to think about what you would study next if you were a scientist leading this research.

What could children investigate?

- Are there any squirrels living in your local environment? Are they red or grey?
- What foods are available for small mammals and birds to eat in your local area?
- Are some foods easier to eat than others? How do you know?

Children could carry out a nature survey to find out some of the answers to these questions. The [Teacher Guide](#) that accompanies this article describes investigations which children can carry out to find out more about adaptation, habitats and conservation.

GLOSSARY

conservationist

someone who works to protect the environment from the damaging effects of human activity

endangered species

a type of animal or plant that might stop existing because there are only a few of that type left alive

mandible

lower jawbone

native

a species that occurs naturally in a region or ecosystem, no human intervention brought the species to the area or influenced its spread to that area

The paper that inspired this work was:

Morphological and functional variation between isolated populations of British red squirrels (Sciurus vulgaris).

By P. G. Cox^{1,2}, P. J. R. Morris³, J. J. Hennekam² & A. C. Kitchener^{4,5}.

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