Scientists use physical experiments, computer modelling to explore efficiency of bladed tooth shape

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Illustration of the experimental and theoretical analyses. Upper left: A picture of the double guillotine testing device used in physical experiments. Upper right: The finite element model created to mimic the physical experiments and allow for further modelling. Lower left: sample of tooth models for experiments made from steel. Lower right: Cheek tooth (carnassial) of a North American Fisher (Martes pennanti) illustrating the presence of V-shaped notched blades in nature. Image by Dr Philip Anderson

Using a combination of guillotine-based experiments and cutting-edge computer modelling, researchers at the University of Bristol have explored the most efficient ways for teeth to slice food. Their results, published today in Journal of the Royal Society *Interface*, show just how precisely the shape of an animal's teeth is optimized to suit the type of food it eats.

There is a massive variety of tooth shapes in the natural world, from long, serrated teeth in Tyrannosaurus rex to triangular teeth in sharks and our own complex molars. Teeth can enable animals to crush, chop, grind or even slice food into pieces small enough to swallow. However, such cutting instruments are not restricted to toothed animals. Bird beaks, insect mouth parts and even the roughened tongue of snails can also be used to break down food.

Given all this variety in tooth form, surprisingly little has been done to examine how teeth are able to cut and break food. Two researchers at the University of Bristol, Dr Philip Anderson and Dr Emily Rayfield, have attacked this problem using a combination of physical experiments and high-tech computer modelling.

Using a unique double-bladed guillotine, the researchers measured the force needed by different tooth shapes to compress food materials. Finite Element Analysis (FEA), an engineering computational technique, was then used to mimic these experiments and allow for different variables to be measured, such as the total energy required. It turns out that different shaped bladed teeth are optimized for different types of food.

Dr Anderson said: "The actual hardness or toughness of the food item has a strong effect on what type of tooth shape is most efficient for cutting it. We looked specifically at V-shaped bladed edges which are similar to tooth shapes found in some sharks and the cheek teeth of many carnivorous mammals, and found that the angle of the V could be optimized for different foods.

"This sort of analysis is only possible because we created a computer model to mimic the physical experiments. With the validated model, we were able to alter aspects of the tooth shape until we found a specific shape which used the least energy."

"These results might seem rather obvious," said Emily Rayfield, "because we know tooth shape is adapted to diet. But we were surprised at the preciseness and predictability of the fit of tooth shape to dietary item."

The researchers hope this new integrated methodology based on experimental analyses and theoretical computer modelling will create a new framework for exploring the evolutionary history of dental shape and how it relates to diet.

More information: 'Virtual experiments, physical validation: dental morphology at the intersection of experiment and theory' by P. S. L. Anderson and E. J. Rayfield in Journal of the Royal Society *Interface*.

Provided by University of Bristol