# Evolutionary adaptation helped cave bears hibernate, but may have caused extinction

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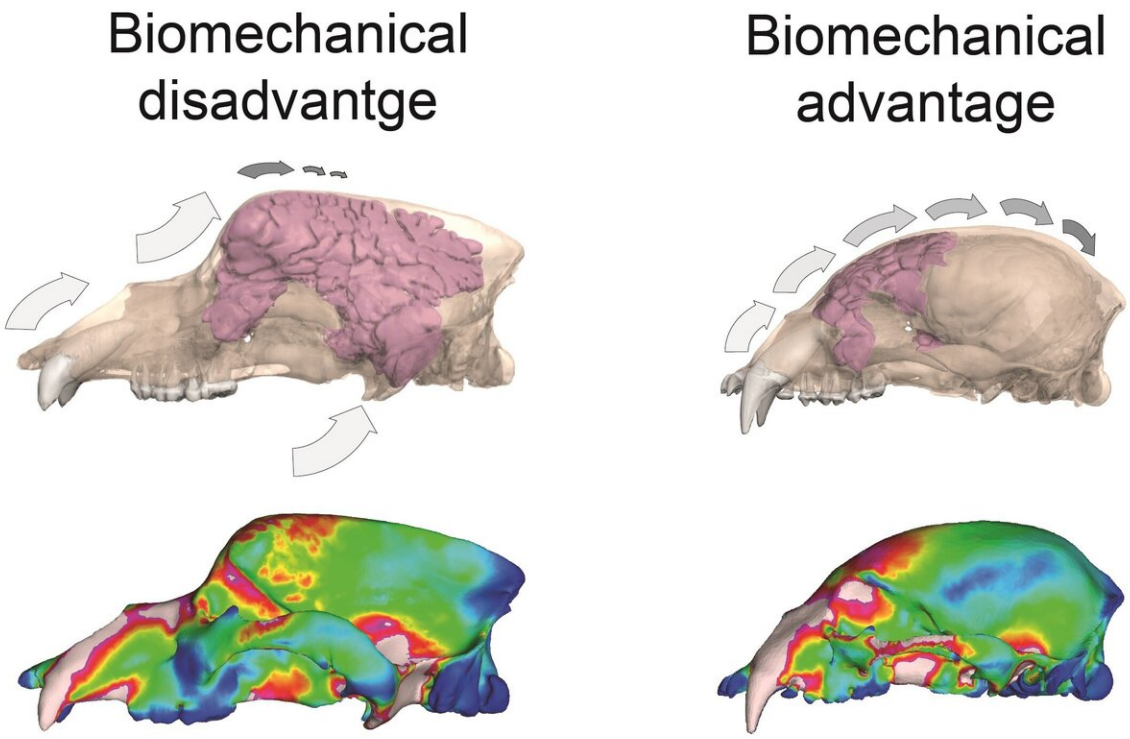


The well-developed sinus system in the now extinct cave bear (top left) is associated with uneven mechanical stress distributions in biting simulations (bottom left) conducted at UB. The much less developed sinus system in living bears, for example the sun or honey bear, (top right) allows mechanical stress to distribute evenly over the forehead region, as seen in the biting simulation (bottom right). Credit: Alejandro Pérez-Ramos

A study published in *Science Advances* on April 1 reveals a new hypothesis that may explain why European cave bears went extinct during past climate change periods. The research was motivated by controversy in the scientific literature as to what the animal (*Ursus spelaeus*) ate and how that affected their demise.

The new hypothesis emerged, in part, from computational analysis and computer biting simulations conducted in the laboratory of Jack Tseng, Ph.D., assistant professor of pathology and anatomical sciences in the Jacobs School of Medicine and Biomedical Sciences at the University at Buffalo.

Tseng is a co-author on the paper with corresponding authors Borja Figueirido, Ph.D., and Alejandro Pérez-Ramos, Ph.D., his doctoral student and first author, both of the Departamento de Ecologia y Geologia of the Universidad de Malaga, Spain.

## Dietary dilemma

Cave bears were a species of bear (*Ursus spelaeus*) that lived in Europe and Asia that went extinct about 24,000 years ago. According to Figueirido, researchers have proposed different diets for cave bears, ranging from pure herbivory to carnivory or even scavenging.

"Knowing the feeding behaviour of the cave bear is not a trivial aspect," he said. "Feeding behaviour is intimately related to its decline and extinction."

He noted that two main hypotheses, not necessarily exclusive, have been proposed to explain cave bear extinction: a human-driven decline, either by competition for resources or by direct hunting; or a substantial

demise in population sizes as a result of the climatic cooling that occurred during the late Pleistocene which caused vegetation to wane.

Previous research shows that cave bears were primarily herbivorous at least from 100,000 to 20,000 years ago. But even during the cooling periods, when vegetation productivity waned, these bears didn't change their diets. The researchers propose that this dietary inflexibility, combined with competition for cave shelters by humans, is what led to their extinction.

To find out if there were biomechanical explanations behind their inflexible diets, meaning that the bears weren't physically capable of adjusting their diets effectively during times of limited vegetation resources, the researchers analyzed three-dimensional computer simulations of different feeding scenarios.

**Critical sinuses**

They were especially interested in the sinuses of the bears because large paranasal sinuses allow for greater metabolic control, critical to survival during hibernation.

"Our study proposes that climate cooling probably forced the selection of highly developed sinuses," which in turn led to the appearance of the characteristic domed skull of the cave bear lineage," said Alejandro Pérez-Ramos.

Tseng explained that when the sinus system expands, the act of chewing may cause more or less strain on the skull. In both humans and bears, the sinus system lightens the weight of the face, reducing the amount of bone tissue needed to grow the skull.

"Mechanically speaking, being 'thickheaded' may not be a bad thing

because more bone means more structural strength," he said. "However, our findings support the interpretation that requirements for sinus system function in cave bears necessitated a trade-off between sinus development and skull strength."

Tseng and Pérez-Ramos, who spent three months at UB to learn the procedure, used a biomechanical simulation methodology to estimate the biting stresses and strains in different bear species and different models of them. The bear skull specimens used were from several European institutions, where CT scans had been done on them, as well as the scientific CT repository, also known as the digital morphology library, at the University of Texas at Austin.

They found that the development of paranasal sinuses in cave bears caused the cranial dome to expand upward and backward from the forehead, changing the geometry of the bear's skull.

"This geometrical change generated a mechanically suboptimal cranial shape, with a very low efficiency to dissipate the stress along the skull, particularly when biting with the canines or carnassials, the teeth most often used by predatory mammals," said Pérez-Ramos.

When the sinus system expands, Tseng explained, it results in bone reduction relative to the size of the skull and therefore less structural support to resist the physical forces that chewing generates. Although other mammals with expanded sinuses, such as hyenas, appear to have evolutionarily modified their skull shape to effectively deal with decreased structural support, cave bear skulls showed compromised biomechanical capability compared to living bear species.

"Through the use of new techniques and virtual methods, such as biomechanical simulations across each tooth and the comparative internal anatomical study of the paranasal sinuses, we propose that large

sinuses were probably selected in cave bears in order to be able to hibernate for longer periods with very low metabolic costs," said Pérez-Ramos.

Ultimately, though, that trade-off may have resulted in the extinction of the species, a finding that also has relevance to humans, Tseng said.

"Being able to stay alive during the coldest periods would have been equally important to human and bear alike," he said. "The success or demise of prehistoric megafauna, such as cave bears, provide crucial clues as to how humans may have out-competed and out-survived other large mammals during a critical time for the evolution of our own species."

**More information:** A. Pérez-Ramos el al., "Biomechanical simulations reveal a trade-off between adaptation to glacial climate and dietary niche versatility in European cave bears," *Science Advances* (2020). advances.sciencemag.org/content/6/14/eaay9462

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