Study of 90 animals' thigh bones reveals how they can efficiently carry loads

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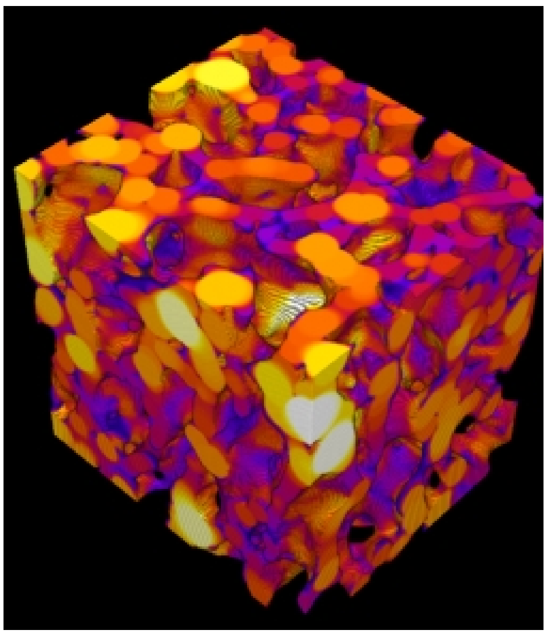

The researcher's discovered that one strut in this elephant's trabeculae is bigger than a Shrew's whole femor

(PhysOrg.com) -- The structures inside animals' thigh bones that enable them to support huge loads whilst being relatively lightweight are revealed in research published today in the journal *Proceedings of the Royal Society B*. The researchers say their work could lead to the development of new materials based on thigh bone geometry.

A team from Imperial College London and the Royal Veterinary College collected thigh bone samples from British museum collections and zoos, analysing specimens of the femur bone from 90 different species including the Asian elephant, Etruscan shrew, roadrunner, crocodile, emu, turkey, leopard and giraffe. They explored how animal size related to the formation of an interlinking lattice of tiny bone struts inside the femur called trabeculae. The researchers found that trabeculae, typically found near joints, have different geometry depending on the size of the species.

The researchers say their new understanding of how femur bones are structured could be used to advance a class of tough, light-weight structural materials, which could be used to improve bodywork for planes and cars.

Dr Michael Doube, lead author of the study from the Department of Bioengineering at Imperial College London, who is also a veterinary surgeon, says:

"Scientists had not previously known that the structure of trabeculae varied, or scaled up, depending on the size of the animal. We assumed that trabeculae would be important in supporting the weight of larger creatures such as Asian elephants, which can weigh more than three tonnes. However, we were surprised to find that animals that have comparatively lighter loads, such as the Etruscan shrew, weighing three grams, also has trabeculae supporting its tiny body. Our study is helping us to see how the remarkable geometry of trabeculae supports loads in all creatures, no matter how big or small they are."

The scientists found that even though the overall amount of bone per unit volume stayed roughly the same in bigger animals and smaller animals, the trabeculae in bigger animals were thicker, further apart and less numerous.

The team suggest that the big trabecular struts inside the bones of larger animals help to support their heavier load without the need for thicker and denser bones. Using this structure saves valuable energy in larger animals because they do not have to grow, maintain and carry extra bone tissue around with them.

The scientists say new structural materials could be developed, which are inspired by geometry inside femurs. These materials would contain a lattice work of stiff foam that would be reinforced in certain areas, depending on the load being exerted on that particular section. This type of material could be used in car bodywork, only being reinforced in areas of the car where loads are heaviest. This could make cars lighter and more fuel efficient.

The team in the study used a technique called X-ray microtomography, which uses X-rays to create three dimensional images of the trabecular bone. This information was fed into a computer where the scientists created over 200 virtual computer models of the bones.

To analyse the bone structure of the 3-D femora models, the researchers also developed an open source computer program called BoneJ that examined different aspects of the trabeculae including the number of struts, their thickness and spacing. BoneJ has been downloaded more than 1500 times world-wide, with hits from over 250 institutes and organisations.

This research is part of ongoing work by the team who are also investigating how leg bones affect the gait and walking characteristics in different species. The information combined from both studies will be used by the team to understand the relationship between how animals walk and bone structure. This could lead to insights into a range of fields including understanding in more detail how bone deformities develop in animals and humans and deducing the movement patterns of ancient species in the field of palaeontology.

More information: "Trabecular bone scales allometrically in mammals and birds" *Proceedings of the Royal Society B* journal, Wednesday 9 March 2011.

Provided by Imperial College London