feathers were also filmed in an air-flow with a high speed video camera, and subjected to morphological examination and biomechanical testing. Video and audio analysis of the feather demonstrated that a fluttering of the trailing vane generated the sound. The flutter of the vane is facilitated by the rearward curvature of the feather shaft, reduced branching angles of the barbs in the trailing vane and the lack of hooks on the barbs, all of which increase the flexural compliance of the trailing vane, especially in a hinge region. Sound production occurred at the same frequency as the vane movements, at frequencies consistent with it being produced by a fluttering flag mechanism but too high to be caused by an Aeolian whistle mechanism.

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A6.4
10:00 Sunday 28th June 2009
Spring or strut? Biomechanical specialisations in elephant limbs

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The fore- and hindlimbs of elephants contain several specialised muscle–tendon units and fasciae. Differences in fore- and hindfoot form and function, with a spring-like ankle and strut-like wrist, appear to be balanced by differences in more proximal limb anatomy, consistent with measurements of similar overall mechanical functions in both limbs.

Here we present qualitative and quantitative anatomical data on the limb specialisations of elephants, with particular reference to the changes in morphology seen across a wide ontogenetic size range (~100–4000 kg). These are then integrated with available biomechanical data to infer possible locomotor function.

Elastic structures are more developed in the proximal fore- than hindlimb and become more extreme during growth. Pronounced flexion of the forelimb appears to be the default position when the muscles are inactive, as indicated by the normal orientation observed post-mortem. This flexed limb configuration is maintained, at least in part, by tension in the thick fascial layers covering the muscles, and is much more pronounced than in the hindlimb.

The elephant forelimb also contains two muscles which have become remarkably specialised when compared with the ancestral mammalian condition. The pronator teres forms a thick, fibrous band in larger elephants, fixing and stabilising the wrist joint in pronation. The flexor carpi radialis muscle is strongly compartmentalised by yellow elastic tissue, creating a long, springy connection between the radius and the carpus. This unusual structure may aid in damping the "heelstrike" impulse at the carpus, making wrist and ankle function more similar in the living elephant than seen in in vitro experiments.

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A6.5
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Geometry and parallelism in the long bones of rodents and ungulates

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Morphological parallelism between South American hystricomorph rodents and small ungulates from the Old World has been postulated for a long time. This research deals with this question from the point of view of biomechanical characteristics of the long bones. For that, cross-sectional area, second moment of area, polar moment, athletic ability indicators and strength were calculated for the long bones (humerus, radius, femur and tibia) of 5 species of Cavioida and 2 species of Artiodactyla. Regressions of each of these variables to body mass were carried out. Regarding the cross-sectional area, the confidence intervals show that the exponents calculated are always higher than the value predicted by geometrical similarity, except in the case of the femur, while exponents obtained for the second moment of area or the polar moment are not significantly different from the predicted values, except for humerus and tibia. The two indicators of athletic ability scaled as expected, except the humerus and tibia axial indicators. The exponent calculated for femur strength is not different from 0, while in the case of the humerus, strength decreases slightly with body mass. Additional statistical tests show no difference between the values of these parameters calculated for the studied samples of artiodactyls and rodents. The present results are consistent with the hypothesis that the parallelism between hystricomorph rodents and small ungulates is very important.

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A6.6
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Allometric scaling of trabecular bone

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The scaling of gross bone shape with size is well-studied. However, the mechanically important interior micro-architecture of bones has been more neglected. We measured trabecular scaling in a broad range of taxa, spanning the 6 orders of magnitude size range from Etruscan shrews (Suncus etruscus) to Asian elephants (Elephas maximus). We acquired 3D microtomographic scans (Metris X-Tek) of entire femoral heads (femoral head radius, $R < 7.5$ mm) or of 10 mm cubes cut from the centre of the femoral head ($R > 7.5$ mm). We cropped images to contain only trabecular bone and then binarised them. Trabeculae tend to increase in thickness as $R$ increases, with greatest maximum thickness ($T_{\text{max}}$) attained in elephant trabeculae ($T_{\text{max}} \propto R^{2.6}$). For perspective, the radius of a mouse's ($Musculus$) femoral head is similar to the thickest elephant trabecula (both $0.77$ mm). For small animals with $R < 10$ mm, mean trabecular thickness ($T_{\text{av}}$) scales strongly with $R$ ($T_{\text{av}} \propto R^{4.8}$). Greatest mean trabecular thickness (0.197 mm) was found in relatively small animals – the mountain hare ($Lepus timidus$) and greater mouse deer ($Tregulus napa$) – possibly related to high acceleration propulsion by the hindlimbs. Trabecular thickness is not associated with volume fraction. Bone volume fraction and anisotropy did not scale with animal size, remaining within a similar range independent of animal size. Measurement of trabecular network parameters such as branch length, connectivity and rod/plate distribution may explain why the largest animals do not have relatively the most trabecular bone.

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