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*Isoodon auratus* | IMAGE: W. Bancroft

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# The anatomy of digging mammals

Anatomy may be one of the oldest sciences, but current work at Murdoch University is providing valuable insights into the ecology and evolution of Australian wildlife.

Though modern molecular analytical techniques can shed light on everything from genes to cell chemistry, our understanding of what animals do and how they work is fundamentally based on our understanding of the architecture of their bodies. This bulletin describes the outcomes of recent studies of the musculoskeletal anatomy of some native marsupials.

Bandicoots and bilbies (order Peramelemorphia) represent the principle group of omnivorous marsupials across Australia and New Guinea. Many bandicoot species (family Peramelidae) dig for subterranean food, while bilbies (family Thylacomyidae) use their forelimbs to dig extensive burrow systems for shelter through semi-arid and arid zones. Digging animals are very important for ecosystem health, and their population declines and extinctions have had significant impacts of Australian ecosystems[1].

**The forelimb of bandicoots and bilbies is well equipped for digging[2].**

The bones of the forelimb, and in particular the forearm, are relatively short, stout bones, which improves both their resistance to mechanical forces and provides a mechanical advantage via a reduced out-lever length. Powerful muscles are required to generate forces to act against the resistance of the soil during digging, and the forelimb of bandicoots reflects two adjustments of the muscles for digging:

1 Increased muscle volume; in part because muscle force is proportional to cross-sectional area, and

2 Improved mechanical advantage, by moving the attachments of the muscles to the bones further away from the joint across which they act (the fulcrum of the lever system).

**FIGURE 1** Articulated skeleton of the bilby (*Macrotis lagotis*). Murdoch University Veterinary Anatomy Museum. In contrast to other marsupials, bandicoots and bilbies present an unusual combination of skeletal features, including plesiomorphic polyprotodont dentition (numerous incisors in the lower jaw), syndactylous morphology of the pes (bound second and third toes), an ossified patella (knee-cap), and they lack clavicles from the shoulder structure. They are the only marsupials to develop a complex chorioallantoic placenta, and though the young are born relatively large and advanced in comparison to many other marsupials, they have some of the shortest gestation periods known for mammals. IMAGE: J. Hong

**The hindlimb anatomy of bandicoots and bilbies is adapted for strong propulsion**[3].

In bandicoots, massive muscle development on the inner thigh contributes to hip extension while at the same time drawing the limbs under the body for forward propulsion. The hamstring muscle group, which form almost 30% of the total hind limb muscle mass, are significant in that they act over more than one joint — hip extension, knee flexion and also plantar flexion. Muscles that affect more than one joint, such as the hamstrings, may reduce the metabolic energy necessary for movement by providing force at two joints by the contraction of only one muscle.

In bilbies, the hind limb muscles are more internally subdivided, which suggests that these muscles contribute contractile force through a wider range of movement or act through a greater range of positions. This seems likely to reflect a greater role of hind limbs during digging in bilbies, where the hind limbs are used to push back soil excavated by the forelimbs.

## Conclusions and future work

Southern brown bandicoots and bilbies are essentially half-bounding, terrestrial insectivores. Whereas the bandicoots prefer close cover and scrubby vegetation in mesic environments, bilbies forage in areas with sparse ground cover through arid and semi-arid zones of Australia.

While the forelimb anatomy of bandicoots appears substantially modified for digging, the hind limb anatomy appears capable of fast powerful limb movements. When taken together with the compact, torpedo shaped body, thick skin and cutaneous muscle layers, reduced ear pinnae and crouched posture, these animal appear to be very well suited to an explosive escape behaviour through dense habitat.

The relatively longer limbed, less-flexed limb posture of the hind limb in bilbies seems likely to represent a compromise between the requirements of hind limb used during digging and quadrupedal locomotion though open, arid country.

Current and future work will further examine the relationship between muscloskeletal anatomy and locomotion in living and extinct species in order to assess how locomotor behaviour might influence the susceptibility of critical weight range marsupial species to extinction. ■

## More information

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## References

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3 Warburton, N.M., Malric, A., Yakovleff, M., Leonard, V., and Cailleau, C. (2015) Hind limb myology of the southern brown bandicoot Isoodon obesulus and greater bilby *Macrotis lagotis* (Marsupialia: Peramelemorphia) *Australian Journal of Zoology*. Early online DOI 10.1071/ZO14087

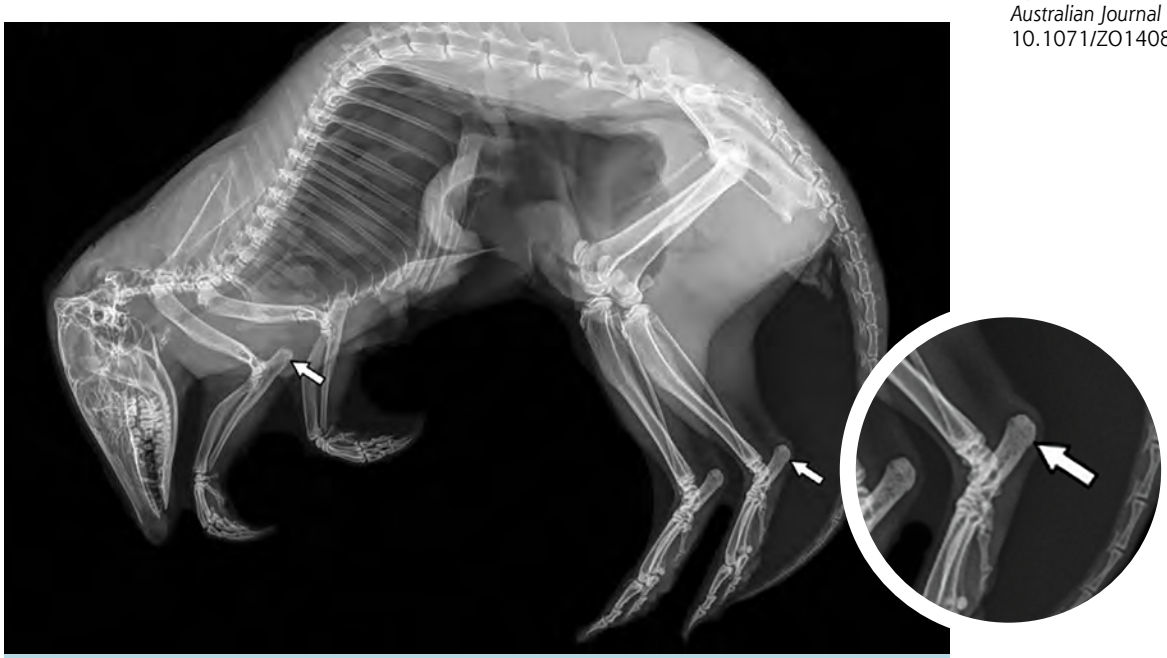

**FIGURE 2** X-ray of a bandicoot (*Isoodon obesulus*). Note the large bony prominences for muscle attachment (arrows). IMAGE: N. Warbuton

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