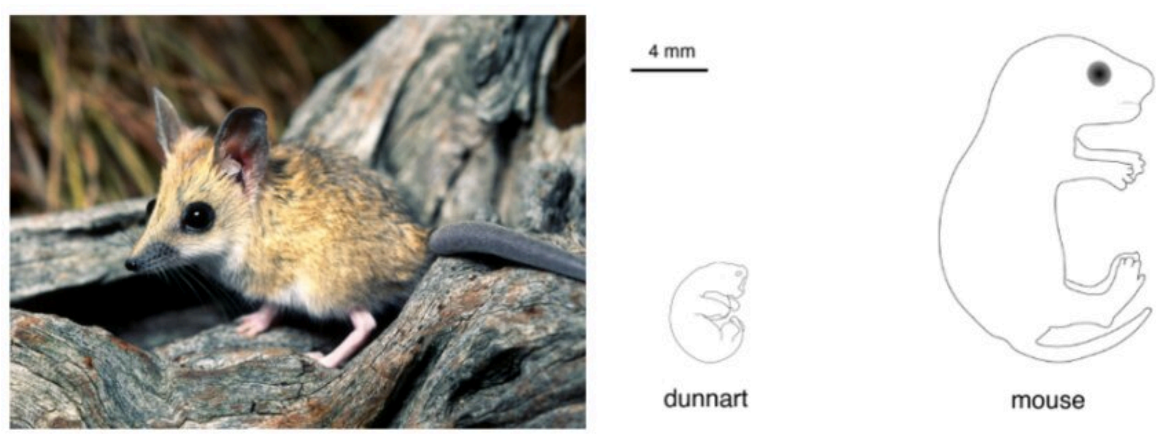
PHYS.ORG

No bones about it, dunnarts crawl before growing a skeleton

September 6 2021, by Laura Cook and Professor Andrew Pask



Adult fat-tailed dunnart and a schematic comparing the extent of development of the fat-tailed dunnart and mouse newborns on the day of birth. Credit: Alan Henderson – Minibeast Wildlife/Supplied

Australia is home to some of the most iconic mammals in the world. Most people would easily recognize a kangaroo, koala, or maybe even a smiling quokka.

It's unlikely however, that you've caught a fleeting glimpse of one of the 19 species of Australia's most elusive marsupials scurrying through the grass at night.

Dunnarts are nocturnal marsupials—mammals who carry young in a pouch—that are often referred to as "marsupial mice". They're so similar to mice in fact, that in cold temperatures, dunnarts have been known to keep warm by sharing their nests with the common house mouse.

However, this is where their closeness ends, since they last shared a common ancestor approximately 160 million years ago.

One species, the fat-tailed dunnart (Sminthopsis crassicaudata) was first described in the literature in 1844 by English ornithologist John Gould and since the mid-1900s has been of great interest to scientists due to its ability to survive in extreme, semi-arid environments.

The fat-tailed dunnart belongs to the Dasyuridae family, which also includes Tasmanian devils and quolls. It has a head and body length of between 60-90mm, tail 45-70cm in length and weighs only 10-20g.

It's one of the smallest carnivorous marsupials, coming out at night to eat insects, spiders, amphibians and even small mammals and reptiles. Its long carrot-shaped tail (almost the same length as its body) stores fat reserves for when food is scarce

They can live in areas ranging from open woodland to arid shrublands, undergoing daily hibernation or torpor, lowering their body temperature and metabolic rate to reduce energy expenditure in response to environmental conditions.

More recently the fat-tailed dunnart is emerging as an important model species for expanding our understanding of the evolution of the mammalian brain, retina development in nocturnal species and as a tool for marsupial conservation.

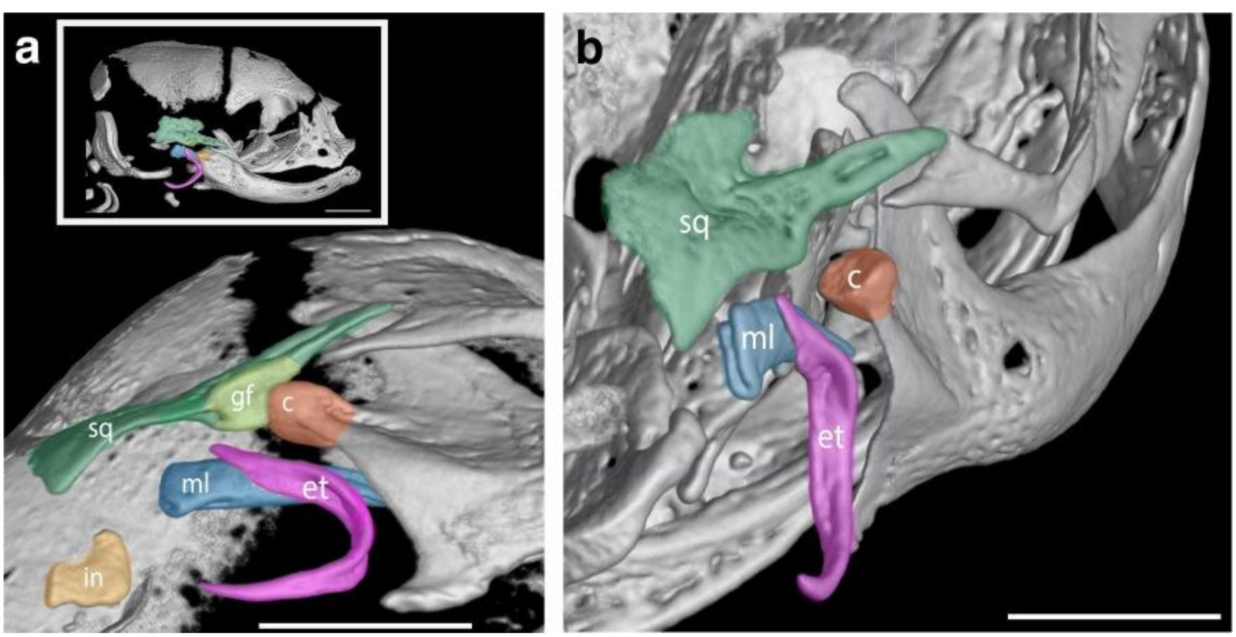
Although the fat-tailed dunnart isn't itself endangered, other dunnart species including the Kangaroo Island dunnart and Sandhill dunnart are.

It is also a Dasuyrid marsupial, belonging to the same order as the endangered Tasmanian devil, the numbat and the extinct thylacine (Tasmanian tiger).

So, because resources for marsupial laboratory models are greatly limited (compared with traditional mammalian models like the laboratory mouse) the fat-tailed dunnart presents an excellent opportunity to develop a laboratory marsupial model, enabling us to learn more about the biology of our unique Australian fauna and develop vital new conservation tools.

To address the huge gap in our understanding of marsupial biology, our research team developed a comprehensive resource—as a reference for other research projects—focussing on the development of the fat-tailed dunnarts from birth to adulthood.

The amazing thing about the dunnart is that almost all their development happens after birth in the pouch, which means we can observe the joeys in real-time without the need for invasive surgical procedures.



Fat-tailed dunnarts need well-developed mouth and nose to attach to the teat, suckle and breathe simultaneously. Pictures show the secondary jaw joints in microCT scans in fat-tailed dunnart pouch young. (a) View of the secondary jaw joint with inset white box showing entire skull. (b) The secondary jaw joint close up; abbreviations of bones: c = condyle (orange), et = ectotympanic ring (purple), gf = glenoid fossa (light green), in = incus (yellow), ml = malleus (blue) and sq = squamosal (dark green). Scale bar = 1 mm. Credit: University of Melbourne

Fat-tailed dunnarts have one of the shortest pregnancies of any mammal—only 13.5 days. When the joeys are born, they are smaller than a grain of rice, with the heart, lungs, and bladder visible through their translucent skin.

In laboratory mice, development of the organs, bones and brain largely occurs during pregnancy.

Our latest research focussed on the development of the bones of the skull and forelimbs.

We were most interested in these structures because marsupials have this extreme shift in the timing of when the forelimbs and oral region appear compared to placental mammals such as mice and humans.

Joeys need to have highly developed forelimbs to crawl to the pouch and a well-developed mouth and nose to attach to the teat, suckle and breathe simultaneously.

Our research team raised a colony of dunnarts and collected joeys from birth to weaning. The young were examined using micro-computed tomography (microCT), a non-invasive imaging tool that provides 3-dimensional (3D) images of the internal structures with very high resolution.

We used this technique to see when the bones and soft tissues first arise.

Surprisingly, we found that on the day of birth, despite crawling to the pouch and attaching to the mother's teat, the joeys had formed no mineralised bone tissue (ossification) anywhere in their body.

The forelimbs, oral and nasal cavities were all highly developed but microCT scanning revealed the complete absence of ossified bone.

This was somewhat of a surprise as we know that other marsupial species like kangaroos and tammar wallabies have accelerated development of the forelimb and oral bones with these bones present before or at birth.

Approximately 24 hours after birth, the first bones were visible in the forelimbs and jaw of the dunnart joeys.

This CT scans series has allowed us to pinpoint when every single bone in the dunnart first appears and will be an incredibly useful resource for studying the evolution of the jaw and forelimbs.

Information on the life history of marsupials addresses fundamental gaps in our understanding of these unique mammals. Sadly, a third of Australia's marsupials are currently facing extinction.

This research enhances the utility of the dunnart model and may assist in conservation strategies in a rapidly changing environment.

These data and a detailed staging series are publicly available.

Provided by University of Melbourne