Marsupials might be the more evolved mammals

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Mammal evolution has been flipped on its head, according to new research that suggests marsupials are the more evolved mammals.

By estimating how the common ancestor of mammals reproduced and developed, scientists have turned over the longstanding belief that

marsupials are more primitive than placentals.

Marsupials have long been considered the intermediate step in evolution between egg-laying and placental mammals, because they give birth to highly underdeveloped young similar to an embryonic state for placentals.

However, new research has revealed that the ancestor of both groups was more similar to placentals than to marsupials, meaning that marsupials have modified their method of reproduction more than placentals have.

The study, published in *Current Biology*, analyzed skulls during different stages of development in 22 living mammal species. Micro-CT scans of 165 specimens helped the research team reconstruct the changes of the skull for these species during this early phase.

Using this data, they estimated how the common ancestor of marsupials and placentals would have developed and compared it with both groups to see which was the most similar.

Professor Anjali Goswami, a research leader at the Museum and senior author of the study, says, "Using this big comparative data set generated from the museum's historical collections, we have been able to flip what we know about mammal evolution on its head."

Using a huge dataset of micro-CT scans of marsupial and placental specimens ranging from embryos to adults, the team measured how their skull shape changes through development and reconstructed how their ancestor would have developed. This showed that marsupials have changed more from than ancestor than placentals have.

"For a long time, people have treated marsupials as 'lesser mammals,'" which represent the intermediate stage between placental mammals and

egg-layers, explains Anjali. "It turns out that marsupials are the ones that are far more evolved from the ancestral form."

"As a member of the placental mammals, we often have this bias that ours is the group that evolution is directed towards, but that's not how evolution works."

How did marsupial and placental mammals evolve?

All mammals alive today can be divided into three groups: placental mammals, marsupials and monotremes. These are easily distinguished by their methods of reproduction.

The largest group is the placental mammals, which give birth to live, well-developed young and comprise about 95% of all living mammals, including humans.

Marsupials also give birth to live young but have a very short gestation period and so the offspring are very underdeveloped and so must be looked after by a parent in a pouch.

Monotremes are egg-laying mammals and are the smallest of the three groups. It contains just five species alive today in two families: the platypus and the echidnas.

It is thought that living mammals all descended from an egg-laying common ancestor that lived approximately 180 million years ago. The therians, which is the group containing marsupials and placental mammals, are thought to have diverged from each other quite soon after, around 160 million years ago.

As the therians evolved away from young being born via an egg, it was originally thought that the live birth of an underdeveloped baby as in

modern marsupials was the natural intermediate stage. However, this study found that this not to be the case.

"What we could clearly show is the marsupial way of developing is the one that's changed the most from the ancestor of marsupials and placentals," says Anjali.

"How marsupials reproduce isn't an intermediate form between egg-laying and placental mammals. It's just a completely different way of developing that marsupials have evolved."

Why do marsupials give birth to underdeveloped offspring?

Placental mammals are born with their four limbs and skulls already well developed, which grow in size as the animal gets older. The gestation period ranges depending on body size but can be up to 22 months in African elephants.

In contrast, marsupials are essentially born in an embryonic state. For example, the red kangaroo gives birth to a baby the size of a jellybean just a month after conception before nursing its young for up to six months.

The hindlimbs and skull of these babies have not fully formed, but the forelimbs and mouth bones are a little more developed. Effectively, the animal has all the parts it needs to crawl through its mother's fur to reach the milk-giving teats and suckle, but not much else. Many marsupials have a pouch which helps to protect the underdeveloped young while they are in this very vulnerable stage

But why marsupials developed this reproductive strategy is still not fully

understood.

"It's been suggested that the marsupial strategy is better if you're living with a lot of environmental instability," explains Anjali. "Placental mammals have long gestation times so if an animal goes through a period where resources dry up, both mother and offspring would likely die because it's all internal."

"With a marsupial, it's a much lower risk strategy because the mother can easily abandon them at a very early developmental stage, so at least the mother can survive and try again later."

While today around two-thirds of living marsupials are found in Australia, the earliest marsupials are thought to have originated in North America. From there, they spread down through South America and eventually made the journey to Australia via Antarctica using land connections.

And yet many placental mammals also lived in South America during this time but seemingly did not manage to make that journey.

"One idea is that marsupials were better equipped to make this journey because of their more flexible reproductive system," explains Anjali.

"So by stretching out development and making it more external to the mother, marsupials may be able to cope better with less stable environmental situations. But this is very much a guess and a hypothesis that needs to be tested."

More information: Heather E. White et al, Pedomorphosis in the ancestry of marsupial mammals, *Current Biology* (2023). DOI: 10.1016/j.cub.2023.04.009