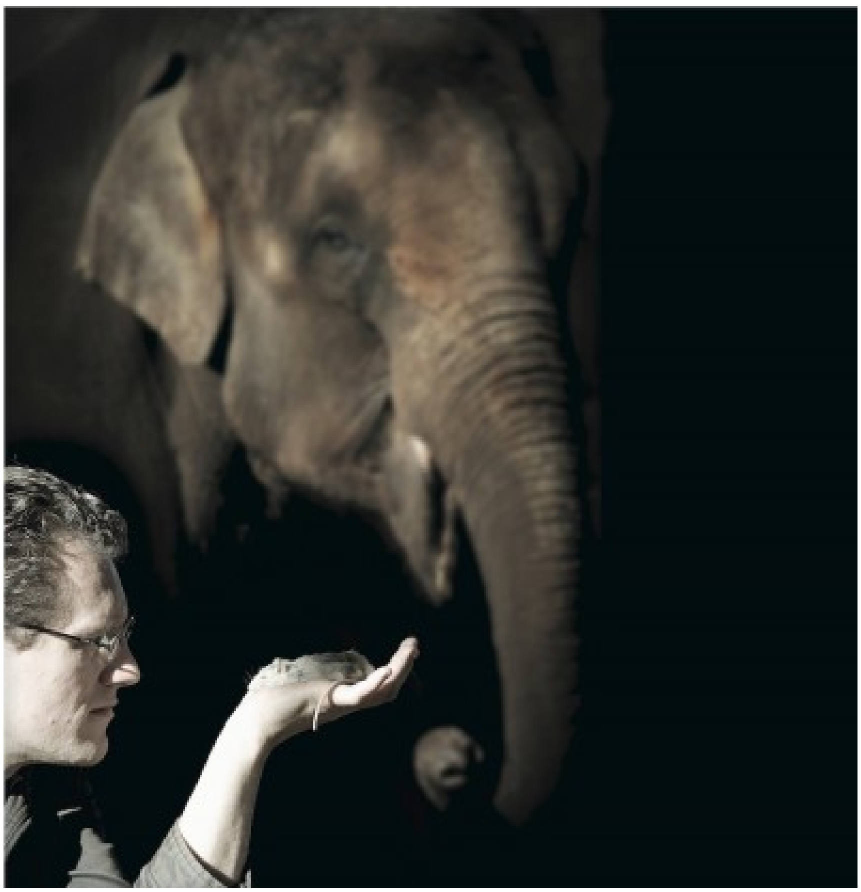
Small winners in the mammalian race to evolve

October 3 2012, by Julian Cribb



Evolutionary biologist Dr Alistair Evans.

It takes at least 10 times as many generations for a mouse to reach elephantine proportions as for the reverse transition, reveals a vast study of mammalian evolution over the past 70 million years.

Between two and five million years ago, something akin to a giant guinea pig roamed South America. Weighing about a tonne, it would have loomed large over its modern relatives – diminutive rodents such as mice and rats.

Such extraordinary contrasts in body mass are part of the story emerging from an international study led by Monash University and published in the Proceedings of the National Academy of Sciences (*PNAS*). The research tells the story of mammalian body size over the past 70 million years.

Body size plays a critical role in survival, explains lead author Dr Alistair Evans, senior research fellow with the Monash School of Biological Sciences. Being large, for example, can help you regulate body temperature in a cold climate. Being small can help you survive when there is fierce competition for food.

"Believe it or not, the ancestors of elephants were once as small as mice," Dr Evans says. "So we were curious to find out how long it would take a 20-gram mouse to evolve into a two-million-gram elephant … and vice versa."

The researchers pieced together the lineages of nine families of large mammals – including those that contain elephants, apes, deer and whales – from the often-fragmentary traces left in the fossil record (the diminutive rodent family was included because of its gargantuan guinea pig relative). By calculating the body mass of each family, they could show how the animals have grown or shrunk over the years. They found that it can take 24 million generations to build an elephant-sized creature out of a mouse, but perhaps only two million generations to create a mouse-sized animal from an elephantine beast.

Previous studies have examined the rate of body mass increase and decrease, but have focused on particular animal lineages; this research looks at entire branches of family trees – the extinct ancestors and all of their descendants. The earlier studies also often focused on shorter time spans, up to only a few million years. The period from 70 million years until present day begins at the point at which mammals started to resemble what they are today, and captures the fascinating complexities in their rise.

But size is a complex matter of adaptability, and Dr Evans explains that bigger is not always better.

"It isn't just about sheer size – it is also about how quickly or slowly you can adjust your size to the changing conditions around you," Dr Evans says. "This can play a crucial role in your chances of survival."

The team chose to measure evolutionary speed in body mass change because it is a fundamental trait, strongly linked to other aspects of the animal's physiology and behaviour.

It is also relatively easy to estimate from fossil remains. To be sure it was getting the whole picture, the team's research took in the world's four largest continents – Africa, Eurasia, and North and South America – and the main ocean basins. It also studied the dwarf mammal populations on islands that had become isolated by rising sea levels, including some in the Mediterranean, Jersey and the Channel Islands of California.

"We chose the generation as our basic measure of evolutionary time, as it is the shortest interval over which evolutionary change can occur," Dr Evans says.

Just before dinosaurs became extinct about 65 million years ago, the largest mammals were tiny, with the biggest discovered fossils from the time indicating a weight of just three kilograms, the size of a house cat.

The emerging picture is one of steady increases in maximum mammal size after the dinosaurs quit the scene, until the peak was reached with the largest mammal ever to walk the Earth: Indricotherium, a 15-tonne cross between a giraffe and a rhinoceros that clomped across the Central Asian grasslands 20 to 30 million years ago.

Since then, things have become more erratic. Broadly speaking, whales have continued to grow up to the present day, while land mammals have tended to stabilise or shrink.

The team's research illustrates how difficult it is to become a giant if you start off small. It takes roughly 1.6 million generations to boost body mass 100-fold, five million generations to boost it 1000-fold (say, from rabbit to elephant size) and 10 million to grow 5000-fold. "We think this is because, as you get larger, everything has to change," Dr Evans says. "You need bigger, stronger muscles; stronger bones to bear the weight; bigger lungs and heart. The whole animal has to evolve."

The shrinking process is at least 10 times faster. The researchers were surprised to find this dramatic rate of change when they came to investigate the dwarf animal populations isolated on islands that were mountain tops before sea levels rose and cut them off, they were surprised to find an even more dramatic rate of change. These animals shrank rapidly from their large savanna-roaming sizes to a fraction of the bulk. Varieties of pygmy elephants, hippopotamuses and deer appeared comparatively quickly – in fact, it seems they sometimes shrank up to 30 times faster than it would have taken them to achieve increases of the same proportions.

"An island population has limited resources," Dr Evans says. "It faces fierce competition with its own kind and with other species. This will tend to drive it to breed at younger ages, resulting in smaller offspring. Selection pressure will naturally favour the smaller ones, which will become parents of the next generation."

The researchers also theorise that it is easier for a mammal to mature and breed early than to grow larger and postpone maturity.

Dr Evans suggests that the same kind of processes could explain the development of so-called 'hobbits', a recently extinct humanoid species whose 2004 discovery on the Indonesian island of Flores sparked much scientific debate. It may also help explain why pygmy human populations in the Congo rainforest – or Bushmen in the Kalahari Desert, where resources are also limited – live isolated amid a continent of generally large humans.

The research also identified a stark difference between terrestrial and marine mammals: whales can evolve from small to large in only half the number of generations required by land animals. They have continued to grow over the past five to 10 million years. The blue whale is thought to be the largest living creature ever to swim the oceans, substantially outweighing the largest marine reptile, and it will continue to increase in mass if other forces do not intervene. Dr Evans speculates that whales require a lot less evolutionary 're-engineering' to support the structural changes because the water supports their weight.

For land mammals, after millions of years of expansion, more recent human and climatic effects appear to be bringing about a reduction in their maximum size.

"There is little doubt that human hunting pressure had a hand in the loss of the megafauna – very large land mammals – in Europe, Asia and America, pushing many to extinction," Dr Evans says. "But even in the past 100 years other forms of human pressure, such as competition for grazing lands, have caused large animals to decline in size. There is good evidence, for example, that African elephants are not as large as they were a century or two ago."

That humans are not only causing some species to disappear but also bringing about a decrease in size of others casts a disturbing new light on the scale of the pervasive impact of human activity on the planet's biology.

Dr Evans says his team's research into rates of evolution is continuing, with a particular focus on modern species and what their genetics can reveal about how rapidly they changed in the past.

"Our results highlight the comparative difficulty of [achieving] major changes in body size, especially increasing in size," the researchers comment in their *PNAS* paper. "[The] substantial length of time illustrates just how challenging this great transformation is."

Provided by Monash University

Citation: Small winners in the mammalian race to evolve (2012, October 3) retrieved 28 April 2024 from https://phys.org/news/2012-10-small-winners-mammalian-evolve.html